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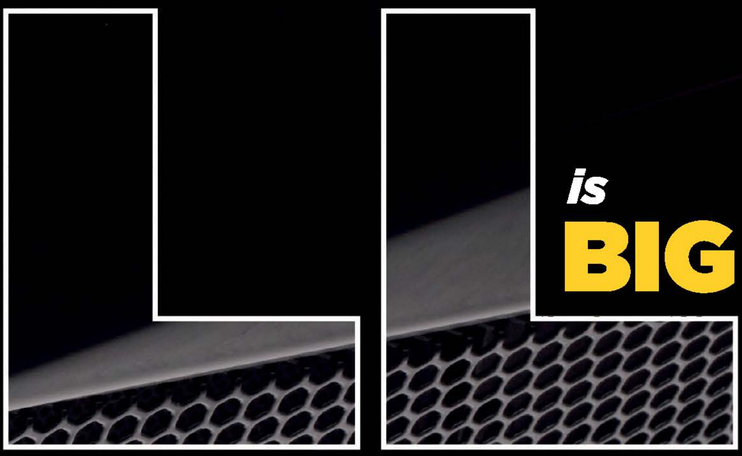

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Tuan
Nguyen

SOMETIMES LESS IS INDEED MORE

IT SEEMS AS THOUGH every company under the sun makes headphones now. Ever since the rise of Beats headphones—which carry a terrible reputation with people who care about audio quality—the industry has gone headphone-crazy. Companies that you'd think would never get into the audio market are making headphones. The same is true now of gaming headsets.

There is an overwhelming number of gaming headsets to choose from. Some are garbage, while others are pretty decent. As you may have guessed, most are made with third-rate components on the cheap. Recently, gamers have begun using normal audio headphones for gaming, paired with a mic.

For people like me who enjoy listening to their favorite tunes through headphones but also dabble with some gaming, I find that the best approach is to pair my favorite cans with something called a ModMic, which is basically a high-quality voice microphone that can be attached to any pair of headphones. Some Googling will reveal that more and more people are using this approach.

Right now, almost all gaming headsets are made by companies with no serious audio experience, except for a select few, namely Astro, Turtle Beach, and Sennheiser. Out of those three, Sennheiser is an exception, because its entire history as a reputable company is based on making quality headphones—they're essentially a reference name for most headphone aficionados. Can gaming headphones even compete? We find out in this month's group test.

Headphones are perfect for when you're gaming on the road. And if you're gaming on the road, you should be gaming on laptops with the latest Skylake CPUs from Intel. Launched late in 2015, Intel essentially made one big promise for laptop users: Incredible battery life for laptops would become reality. For the most part, the dream is real. The worst part of Skylake, though, might just be that there are nearly 50 different models to choose from—some we haven't even seen in our Lab.

Skylake also introduced a new integrated graphics option. I know, I can already imagine you grinding your teeth. But honestly, Intel's latest graphics chops aren't bad at all, and if you look at the stats on Steam, a whopping 46 percent of people play their games on Intel HD graphics. Whatever your case may be—gaming or working—we'll sift through the mobile Skylake details and give you the lowdown on what's really worth buying.

In the world of tech, there are times when plenty of options are available. Many brands, many products, and a sea of speeds and feeds. The old adage goes something like, "Competition is good for the consumer." Sometimes, though, so much competition produces trash for products. Fortunately, we're here to help you sort through what's worth your consideration, and your money.

Tuan

Tuan Nguyen is Maximum PC*'s editor-in-chief, also known as "the pointy end of the stick." He's been writing, marketing, and raising hell in the tech industry for 19 years.*

↘ submit your questions to: comments@maximumpc.com

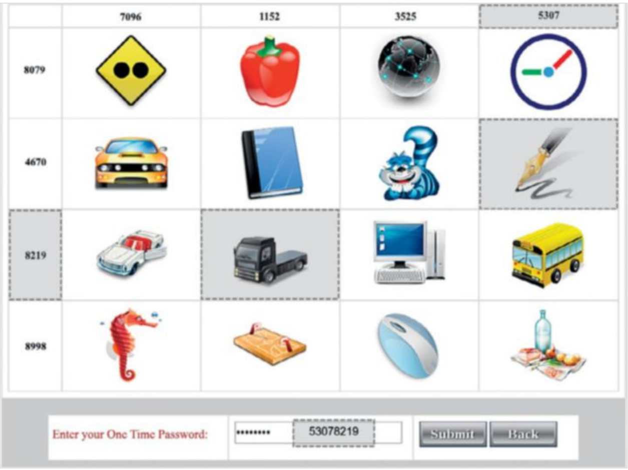
THE NEWS

Solving the Password Problem

Is it time to move on from passwords?

MOST OF YOU reading this probably weren't around in the 1920s, but had you been alive, you might remember visiting a speakeasy, a secret establishment that served alcohol during Prohibition. To gain entry, you'd tap on the door and mutter a password, and if it was correct, you could enter. It was a simple system, and nearly a century later, we're still using the same basic concept, though it's not to keep alcohol under lock and key—it's to protect our online accounts. The question is, should we be?

Username and password combinations grant us access to banking sites, healthcare portals, and other places on the web where we don't want strangers poking around. The problem is, hackers are relentless in their pursuit of our digital data, whether it's to steal our identities and commit credit card fraud, swipe industry secrets, or any other nefarious purpose that drives them. All they need is the right password.



The future of passwords could involve a combination of inputs, such as image recognition and traditional password entry.

This is why some are calling for the death of simple passwords in favor of stronger measures, such as biometrics and two-factor authentication. There's even talk of devices that can be ingested or injected into the body to confirm a person's identity, though not everyone agrees that passwords have run their course.

"Passwords are much-maligned and with good reason—we have a long-term track record of using them badly. However, at least part of this will come down to ignorance rather than negligence, because in many cases very little is done to actually educate users about what good password practice looks like," Steven Furnell, professor of IT Security at Plymouth University, told us.

> The problem is, hackers are relentless in their pursuit of our digital data.

Furnell puts some of the blame on websites, pointing out that most of them don't provide users with proper password guidance. "As such, it is perhaps unsurprising to find that users can get away with making very weak choices—such as those regularly revealed in the annual list of worst passwords published by SplashData."

SplashData's 2015 list of the worst passwords (based on two million leaked ones) contained entries such as "123456," "password," and "qwerty," to name three of the top five.

The problem with stronger passwords is that they're harder to remember. That's where password managers such as LastPass can help. We asked LastPass for its thoughts, and although it thinks passwords will be around for a long time, it acknowledged that it's "looking at what comes next and new ways to augment passwords." One way is single sign-on authentication, a process that allows a user to enter a single name and password to access multiple applications.

"This is a viable alternative to the password because it passes secure authentication data between the user and a service, while entirely eliminating the element of a password. Any cloud service provider can offer single sign-on for their service with SAML 2.0 since it is an industry-wide standard," a LastPass spokesperson told us.

Yet another alternative is multifactor authentication. A recent study by Plymouth University came up with a system called GOTPass, which uses a combination of an unlock pattern, image recognition, and traditional username and password. The advantage of GOTPass is that it's both easy and cheap to deploy. **–PL**

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Reclaiming the web

FORMER MOZILLA CEO and JavaScript creator Brendan Eich has resurfaced in the news with the launch of a new company called Brave Software. What's the new startup focused on? An open-source web browser called Brave. The browser, version 0.7, launched to early adopters and testers on Windows, Mac, iOS, and Android.

According to Eich's blog, the browser blocks ad-click confirmation signals, impression-tracking signals, and signaling/analytics scripts. On a web page, Brave will insert a few new "clean" ads into standard-sized spaces that are found by a cloud robot. He also said that the browser will target ads that are based on "browser-side intent signals phrased in a standard vocabulary." The use of re-identifiable cookies and persistent user IDs will not be permitted.

"The browser sees everything you do, including actions to stop that annoying phenomenon of retargeting where an ad chases you around the web, often for something you just bought or decided not to buy," Eich writes. "We keep user data out of our cloud Brave Vault by default. It's better for you and us that we don't store any of your data without your permission."

Brave promises faster browsing because it blocks trackers and intrusive ads. It also promises safer browsing due to its ability to block third-party tracking and "malvertisement," and direct traffic to HTTPS sites automatically. Users can also see ads that supposedly "respect your privacy," or pay sites for ad-free browsing.

Brave also aims to compensate websites and content creators without the use of ads. "Our premise is that the web requires ads for much of its funding, but not the poorly performing ads and trackers that drive users to ad-blockers. And we want to enable micropayments as an alternative, without requiring infrastructure changes from websites and publishers," Eich said in a follow-up blog post. **–KP**

WINDOWS 10 DEVICES TOP 200 MILLION MARK

OFF TO A FAST START

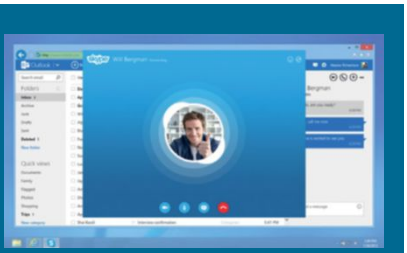
MICROSOFT RECENTLY ANNOUNCED that Windows 10 is now running on over 200 million devices. For those who think that figure is inflated by counting users who upgraded to Windows 10 and then rolled back to a previous version, that isn't the case. In no uncertain terms, Microsoft says, "There are more than 200 million monthly active devices around the world running Windows 10," with the key phrase being "monthly active."

One could argue that a monthly active count is a snapshot that could still be thrown off by downgrades that wouldn't be factored in until the next month, but those would be offset by upgrades (at least partially).

The point is, Windows 10 is gaining ground without any number-counting shenanigans. And to drive the point home, Microsoft says that engagement on Windows 10 is the highest of any version ever, with Windows 10 users logging over 11 billion hours in December. **–PL**

SKYPE HIDES IP ADDRESSES

Vengeful gamers are thwarted



ATTENTION, GAMERS AND STREAMERS: Go update your Skype installation. The reason why is because the latest build finally hides IP addresses by default.

"Starting with this update to Skype and moving forward, your IP address will be kept hidden from Skype users. This measure will help prevent individuals from obtaining a Skype ID and resolving to an IP address," the Skype team announced in a blog post.

Microsoft is targeting gamers with this update. Why? Prior to this, it wasn't that difficult for a sore loser on the Internet to discover a person's IP address based on their Skype ID, and initiate a DDoS attack. There are several sites and services called "resolvers" that offer to do the dirty work, so even non-programmers could obtain a Skype user's IP address with little effort. **–PL**

Tech Tragedies and Triumphs

A monthly snapshot of what's up and down in tech

TRIUMPHS

TWICE AS NICE
CyberPowerPC started selling a setup with two PCs in a single case—one for gaming, one for streaming. No more sharing resources!

KICK-ASS PRICE CUT
AMD gave small form factor builders some love by cutting the price of its R9 Nano by 23 percent to $499.

HIGH ON HELIUM
Seagate released a 10TB hard drive filled with helium. It doesn't float, but the 3.5-inch, seven-platter HDD will help data centers store more files.

TRAGEDIES

NO LOVE FOR DETACHABLES
IDC reported that 2015 was the first year since 2008 that PC shipments dipped below 300 million, but didn't include 2-in-1 devices in its tally.

MORE LOSSES
AMD ended 2015 with a thud, posting a $102 million loss in Q4, but hopes Polaris will lead to a profit in 2016.

POWER TRIP
Microsoft and Apple issued recalls, the former for certain Surface tablet power cords, and the latter for some Mac and iOS AC adapters.

Dave James

TECH TALK

AMD, Polaris, and the Great GPU Arms Race

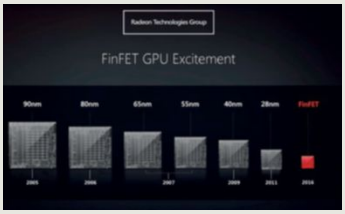
AMD DROPPED THE FIRST GRAPHICS BOMB of the year when it announced the new Polaris GPU architecture. Promising the sort of performance and efficiency gains we haven't seen from AMD in generations, Polaris is taking the fight to Nvidia with the full force of the 14nm FinFET process.

This is going to be quite a year for graphics geeks. It's maybe 12 months later than we might have hoped, but the big die-shrink showdown is about to drop, and both the red and green sides of the great graphics divide are ready and waiting with new GPU technologies to help fire pixels down our eye tubes.

AMD got everyone's geek glands swelling with the announcement of its new Polaris architecture at this year's Consumer Electronics Show in Las Vegas. The reason it's so exciting is that AMD has finally got the smaller production process it desperately needed to compete with the architectural efficiency gains that Nvidia's Maxwell GPUs produced.

Nvidia preempted the failure of the last drop in transistor lithography, from 28nm to 20nm, by making a real push for efficiency in its last-gen GPU, while AMD seemed to be putting all of its eggs in the production process basket without seeing gains elsewhere. Well, apart from high bandwidth memory (HBM)....

Anyway, the fabs making the 20nm chips made too many broken ones, without the power and efficiency boosts needed to make the pricey GPUs viable.



Radeon Technologies Group

FinFET GPU Excitement

90nm 80nm 65nm 55nm 40nm 28nm FinFET

2005 2006 2007 2009 2011 2016

GPU production processes stalled recently, but that's set to change.

Now things are different. Everyone's steering clear of those broken 20nm planar transistors, while AMD is giving the bird to 16nm and going straight for a 14nm FinFET process with GlobalFoundaries.

> AMD is giving the bird to 16nm and going straight for a 14nm FinFET process with GlobalFoundaries.

The 20nm process was a nightmare because of the physical effects of shrinking performance parts to that level. The flat, 20nm planar transistor suffered from electrical leakage, prompting the jump to FinFET, or 3D transistors. Remember when Intel shifted to 22nm Tri-Gate transistors? The GPU industry is following suit.

The 3D transistors—used in AMD's 14nm and Nvidia's 16nm Pascal GPU architecture—make it far easier to control electrical current and reduce leakage. By significantly cutting the wasted energy used simply by turning on a GPU, and coupling that with the inherent efficiency gains of a smaller production process, this year's cards are going to introduce a whole new world of efficient graphics architectures.

"The target we set was to do console-class gaming on a thin and light notebook," explained Raja Koduri, head of the newly minted Radeon Technologies Group. He was demonstrating that lower-end, console-class Polaris GPU and showing off a high-powered enthusiast GPU at CES. And the demo was impressive. Set against a GTX 950, the Polaris GPU was running at 86W in total platform power, with the green machine topping 150W, both running *Star Wars: Battlefront* on a 60fps limit.

If the high-powered Polaris nets the same efficiency gains, we are in for a treat when Polaris drops in the summer. But it's also a relief to hear about low- and high-end versions of Polaris, given that we've been stuck with so few new GPUs and so many rebrands over the last generations.

Now we just need the Zen side of the AMD equation to balance up, and maybe AMD won't have to keep using Intel CPUs when demonstrating its new GPU architectures.

Dave James has been building and writing about PCs and their components for the last two decades.

Windows 10

AMD

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Cortana available in select markets at launch, experience my vary by device.

*External monitor must support HDMI input [If continuum-compatible accessory is not included, add: "Accessories sold seperately."] **App availability and experience varies by device and market. Office 365 subscription required for some features. 1Limited to select premium phones at launch. Feature and app availability and experience may vary by market and device. Windows Hello required specialized hardware, including fingerprint reader, illuminated IR sensor or other biometric sensors.

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Alex Campbell

OPEN SOURCE

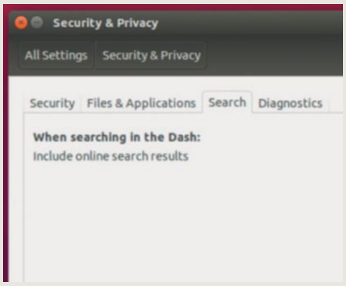
Say “Hello“ to the Xenial Xerus

WHEN SOMEONE WANTS to get started and dive into the world of Linux, it can be overwhelming. There's a ton of new terminology, and plenty of different distributions to choose from. But few of those distros are as user- and newbie-friendly as the old orange-and-purple Ubuntu.

Ubuntu, in my mind, is one of the most important distributions in the GNU/Linux world. (I say this as an avid Arch user, by the way.) Ubuntu has always prided itself as user-friendly, with a simple and intuitive desktop environment called Unity. I remember when I first installed Ubuntu (version 9.04), and felt at home with the familiar GNOME 2 desktop. When Unity came out with 11.04, it shook up my world. I despised the change, and the dock on the left side of the screen.

Love it or hate it, Unity has become one of the main faces of the Linux desktop, right there with GNOME, KDE, and now MATE. As much as some like to complain about Unity (I'm still on the fence about it myself), even GNOME's Activities panel feels an awful lot like Unity's Dash. In an OS where people get really passionate about their desktops and tend to do things one way for a decade (GNOME 2 was released in 2001, while GNOME 3 didn't come out until 2013), it takes cojones to push change on users who could still be easily scared back to Windows.

Canonical, the for-profit company behind the Ubuntu project, first released the Debian-based Ubuntu 4.10 back in 2004. Ubuntu has flourished ever since, releasing new versions of the OS every six months or so. Long-term support versions are recommended for most production servers and desktop users, and LTS versions receive five years of updates and support. Ubuntu 12.04 (Precise Pangolin), released in April 2012, will continue receiving support until April 2017. Likewise, 14.04 will be supported until April 2019.



When searching in the Dash:
Include online search results

The Dash has web search disabled by default in Ubuntu 16.04.

In case you're wondering, Ubuntu's release numbers follow a simple formula: It uses a two-digit year followed by a two-digit month (YY.MM). Ubuntu releases a new version every year, including an LTS version that ships every other year. In this way, Ubuntu mirrors the "tick-tock" formula that Intel uses for its CPUs. This year marks a "tock," with the arrival of 16.04 LTS (aka Xenial Xerus) .

There's no accurate way to know how many users Ubuntu has, since there's no registration requirement, and raw download numbers aren't an accurate measure of install base. But reports keep pointing to the fact that Ubuntu's been killing it in the cloud and server space. On top of that, if you count the derivative flavors such as Mint and Kubuntu, the OS makes up a huge share of the Linux desktop space.

That's not to say there hasn't been controversy over the OS. Ubuntu's implementation of web search in the Dash in 14.04 sent desktop search strings to Canonical, not unlike what Cortana does for Microsoft. (Ubuntu 16.04 will turn this off by default.) That upset privacy advocates, who turn to Linux for its relative privacy compared to Windows. Then there's the choice to use the desktop Mir over Wayland or X, and Canonical's not-so-warm-and-fuzzy approach to licensing the code for Mir. But when you're the 800-pound gorilla in the room, people tend to pay attention and scrutinize your decisions. Had Canonical not been such a big player in shaping the Linux ecosystem, this type of action would not have gotten nearly as much attention.

When it comes down to it, you really can't talk about Linux without talking about Ubuntu these days. And it's actually not a bad OS from a user perspective. If you've never tried Linux, I suggest you go download a copy of Ubuntu 16.04 to a USB stick and give it a whirl. It will literally cost you nothing more than your time. Who knows, you might just be motivated to learn more.

> In an OS where people get really passionate about their desktops, it takes cojones to push change on users.

Alex Campbell is a Linux geek who enjoys learning about computer security.

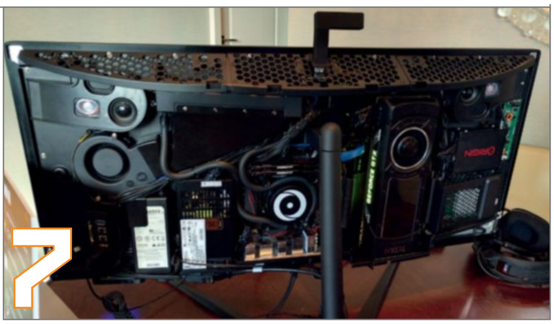
THE LIST

THE COOLEST THINGS WE SAW AT CES 2016

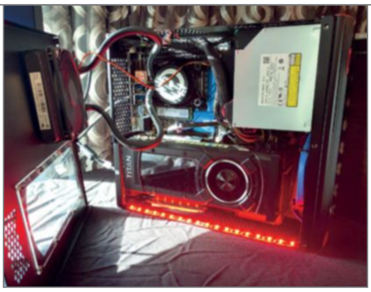
8

IN-WIN 805 Nicknamed "the Black Hole," In-Win uses mirrors to create the optical illusion that the case's darkness goes on forever.

7



ORIGIN OMNI The Omni is a gaming all-in-one that can house a Haswell-E CPU and a Titan X GPU!



6

ORIGIN PC CHRONOS We love small, powerful gaming systems, and it doesn't get much smaller and more powerful than Origin's Chronos.

5

MSI VORTEX MSI's trashcan-shaped PC might remind us of the Mac Pro, but it houses two GeForce GTX 980 GPUs in SLI.

4

ECS H110SU-02 ECS is working on a new mini STX form factor from Intel that's roughly 5x5 inches in size.

3

DEEPCOOL'S LIQUID-COOLED PSU DeepCool is working on a liquid-cooled power supply because... well, why not?

2

HTC VIVE Dev kit two adds a front-facing camera, improved optics, and more ergonomic controllers.

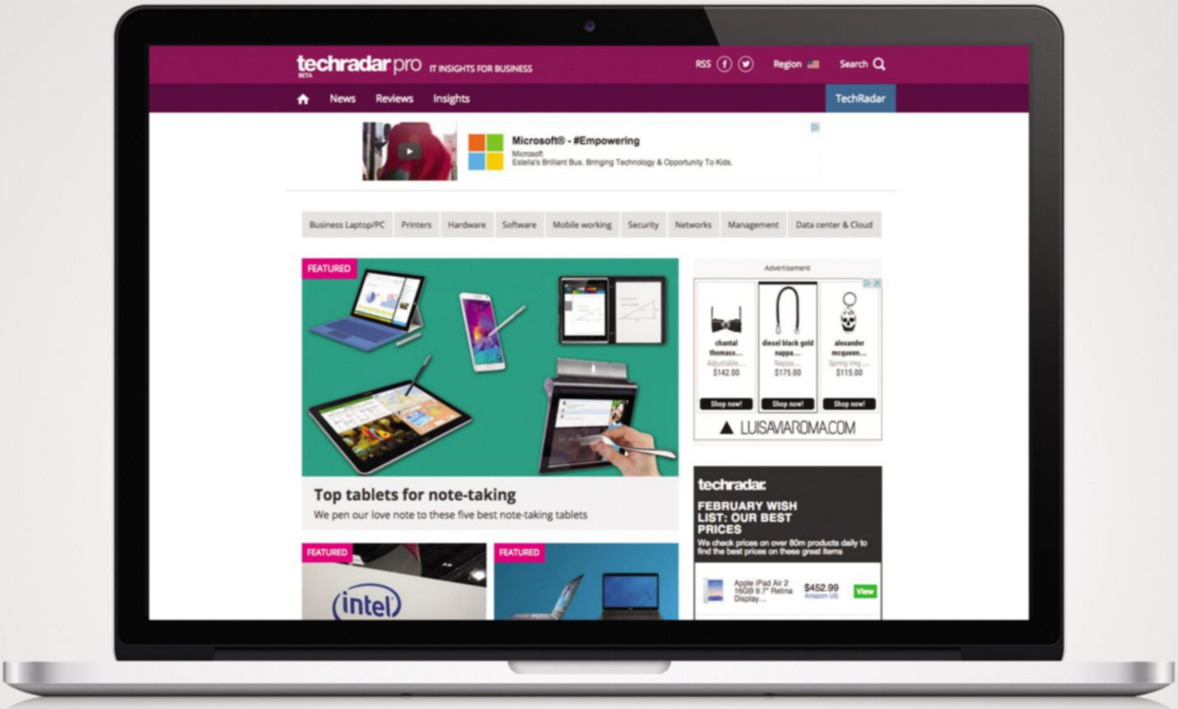
1

OCULUS RIFT We got to try on the final retail version of the Rift and it's the sharpest one yet.

Future

techradar.pro

IT INSIGHTS FOR BUSINESS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TALKING

BY **JIMMY THANG**

Shin from HTC Discusses Vive VR

We speak to HTC about its latest iteration of Vive VR and what differentiates it from the pack

With the Oculus Rift's launch price confirmed at $600, it's not surprising that a vast swathe of us were left a little disappointed at how far VR's prodigal son fell (thanks Mark Zuckerberg!). Fortunately, VR isn't a monopolized medium, and the likes of HTC and Open VR are providing alternative solutions to our virtual reality woes. We spoke to Shin from HTC about its latest version of the Vive headset, and what makes it so different from the competition.

Shin from HTC speaks about the innovative new camera included in Vive's second iteration.

Maximum PC: *Maximum PC* here at CES, and we're in HTC's suite speaking with Shin. So, Shin, you're holding HTC's latest Vive headset—can you tell us what it is that makes it different and new this time around?

Shin: So this is our new headset, but we also have new controllers, and also our new bay stations. Let's start off with the headset. So now we have a much smaller, compact design, and a more ergonomic strap for your head, so this will feel more comfortable. Our gasket will allow you to fit your glasses even more comfortably, but also on the tracking side, these trackers are now much more accurate, and along with our new bay stations, which are much more silent and provide an even better tracking experience, it all provides a much greater tracking experience. So now we also have the front-facing camera, which will allow you to have a peek into the real world, especially when you get too close to the edge, or you can actually activate it manually. By double-tapping the system button, you get a rough outline of your front surroundings in real time.

MPC: Can you tell us a little more about that front-facing camera? We've had a go with this, and it's almost like sonar in a lot of ways. It's a different type of camera—can it act as a traditional camera?

Shin: It is an actual traditional camera—there is a way to activate it so you can see the actual camera. So it's actually just a normal camera sensor with a very special lens, which is calibrated, so it's at a 1:1 perspective, and what it does is it projects on to your hard boundaries around the room. So it gives you a kind of depth, but it's not actual depth, because it's just a single camera, but your brain is tricked into thinking, yep, that's depth.

MPC: For the room configuration, it's really interesting, because you still have the guidance chaperone system—does that use the camera at all?

Shin: So in the first kit, you only had the gridlines that kept you safe. What we've done now, not only do you get the gridlines, but the input from the camera also slowly fades in, so you get a rough outline. What that actually provides you with—when people set up their room

With refined optics, the new Vive VR feels a lot crisper.

and the hard boundaries are around tables or something—is it will let you know which spaces you can actually extend outside the hard boundaries, without hitting anything.

MPC: And it tracks the controllers, right, not just the headset?

Shin: The camera doesn't do any tracking, it just gets processed, and it shows up as part of your chaperone.

MPC: Can you talk about the new controllers? We can see that there's a new button on there—I believe that enables you to see your surroundings a little bit better.

Shin: So with these controllers, the input is almost exactly the same as before—the only difference is with the two buttons located at the bottom; one of them has been moved to the top. So this used to be the small black button, this is the system button. The biggest change is that now these are dual-phase trigger buttons, so it will know when you're halfway pressed down and fully pressed down—it gives you a few more interaction possibilities.

MPC: So you could lightly tap the button halfway, and then press all the way down to grip harder, for instance, or something similar?

Shin: Exactly.

MPC: We know that HTC is working closely with Valve on this one. Is it going to have a large amount of Steam integration when it launches?

Shin: Well, this entire thing is powered by open VR, and one of the things that we use is Steam VR, which is open VR with Steam integration.

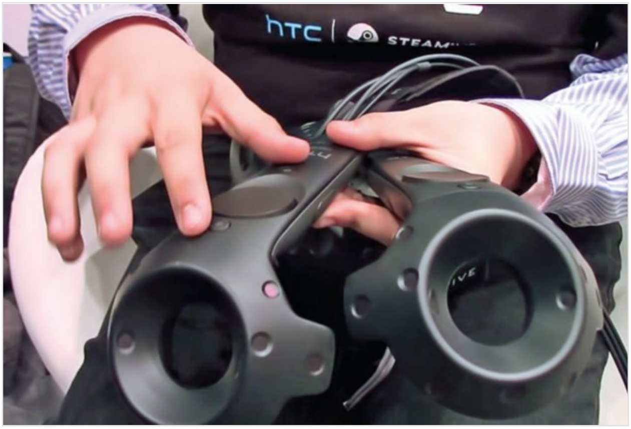
MPC: Can you talk about the resolution and the optics at all?

Shin: Yes. So with this headset, we've refined the panels and the optics, so now it will feel sharper and brighter. The panels are still 1080x1200 pixels per eye, and still running at 90fps.

MPC: Are you guys doing anything with the optics to help out with that? We noticed that for a 1080p screen, it's actually pretty sharp.

Shin: We're always refining every part of the hardware.

MPC: And this is the second generation—is the consumer version going to be like this? Are you guys going to have integrated speakers, or an integrated headset for audio? Or are people going to bring their own?



The buttons have moved, and there are new dual-phase triggers.

Shin: We will have an integrated audio solution, but we haven't really talked too much about that yet. We will reveal more details about it. The consumer edition will have a few changes—this is still just the Vive Pre.

MPC: Will the audio be closed-ear, or open-ear?

Shin: We will talk about that closer to launch.

MPC: Speaking of launch, do you have a rough timeline for when that might be?

Shin: So pre-orders begin in February, and then we will begin shipping in April.

MPC: And do you have a price set yet?

Shin: No, not yet—but we are going to announce it closer to pre-orders.

MPC: Have you announced what kind of specs we're going to be needing to run Vive?

Shin: No, we haven't announced minimum specs yet, but our recommended specs for a good VR experience are something like a GTX 970 and above, or any AMD equivalent—not just Nvidia.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

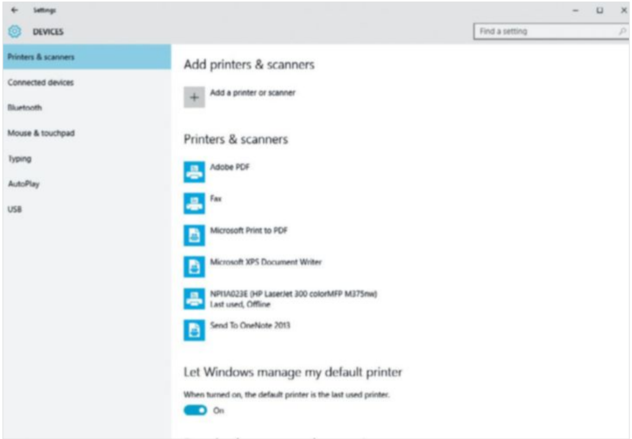
> Win 10 Printers
> Storage Lore
> The 4K Blues

Windows 10 Printers

Hello Doc. My default printer in Windows 10 keeps switching to whichever device was used last. I noticed this after a recent "major" update (I assume it was major because the computer did the same thing after I upgraded from Windows 7).

I have an HP laser printer set to default, but I frequently print to PrimoPDF. When done, I want to create a paper copy. Instead, Windows brings up PrimoPDF again. I have to go to "Devices → Printers & scanners" to switch back. The only other way to change it is to manually print something to the HP. Can you help please? **–Joel González**

THE DOCTOR RESPONDS: Microsoft added this behavior in its November 2015 update. To reverse it, go back to "Printers & scanners," and deselect the option at the bottom called "Let Windows manage my default printer." Do note, though, that if you print to a PDF, then want to create a paper copy of the same document, PrimoPDF will show up as the printer of choice, even though the HP is set to default.



Let Windows manage my default printer

When turned on, the default printer is the last used printer.

On

If you don't want Windows 10 to set your last-used printer as the default, tell it to stop in "Printers & scanners."

Upgrade Wisely

I built a system two years ago based on an ASRock X79 Extreme 6/GB motherboard. I picked a Core i7-3820 CPU, thinking I could upgrade it later, once the higher-end models came down in price. I also assumed that picking the Socket 2011 interface (instead of LGA 1150) would future-proof the system for longer.

Well, the 1150-pin interface appears to be going strong still, while LGA 2011 was replaced by 2011-v3. The CPU prices never did drop, and availability seems to be drying up, leaving me few upgrade options. I'm happy with the performance of my Radeon HD 7900-series GPU for gaming, but I'd like to improve video rendering times using Pinnacle Studio. One option would be to buy a Xeon processor, although they're very expensive. Can you suggest any alternatives? And will I be able to upgrade the CPU if I run Windows 10? **–Bob Kane**

THE DOCTOR RESPONDS: If it makes you feel any better, Bob, LGA 1150 was supplanted by LGA 1151 last year when Intel launched its sixth-gen Core processors based on the Skylake architecture. And although certain fifth-gen (Broadwell) Core CPUs do drop into LGA 1150, they're not particularly enthusiast-oriented parts. Really, the Devil's Canyon Core i7-4790K and Core i5-4690K were that platform's climax, and they're a year and a half old.

Your best bet for an upgrade might be a Core i7-4930K, if you can still find one. It's a six-core chip with 12MB of last-level cache, 40 lanes of PCIe 3.0, DDR3-1866 support, and a higher max Turbo Boost clock rate—all upgrades over the 3820K. And upgrading should be fine under Windows 10.

If you're specifically looking to improve performance in Pinnacle Studio, a graphics upgrade might be in order. Corel does an incredibly poor job enumerating how its software takes advantage of hardware acceleration. However, the latest version explicitly supports Intel QuickSync and Nvidia CUDA—no mention of OpenCL. Further, it appears that rendering and exporting both utilize GPU resources of supported cards.

Slow Skyrim

Hello Doctor, I use a PC that I built back in 2009 to play games and watch videos. Since then, I upgraded its graphics card, added a soundcard, and installed an SSD. I have an Intel Core i7-920 CPU, Asus P6T motherboard, 12GB of OCZ Gold RAM, a GeForce GTX Titan, an Asus Xonar Essence STX soundcard, Samsung's 256GB

↘ submit your questions to: doctor@maximumpc.com

840 Pro, a Corsair CMPSU-850TX PSU, and Windows 10.

When I upgraded to the Titan in 2013, I could easily play *Skyrim* at its Ultra preset. Over time, I added the PCIe-based soundcard and started experimenting with game mods. I began to notice performance degradation and had to tone down the detail settings. I'd like to go back to playing at Ultra and I'm worried about frame rates in newer/upcoming games.

The Asus P6T only has second-gen PCIe x16 slots and I have the soundcard in one of them; could that contribute to the performance issues? **–Jay**

THE DOCTOR RESPONDS: Intel's X58 Express chipset, which the P6T employs, offers 36 lanes of second-gen PCIe. Asus's mobo taps into them through two 16-lane links and one x16 slot wired up to four lanes. You have more than enough PCIe connectivity. The soundcard probably isn't to blame.

It's far more probable that the mods are slowing *Skyrim* down, though the Doc can't say for sure without knowing whether you're enjoying higher-res textures, amped-up weather effects, new gear, or some other game tweak.

Consider that you might have a background process affecting frame rates, too. *Skyrim* isn't particularly graphics-intensive. In fact, it scales well, based on processor performance. So if something else is going on while you play, that aging Core i7-920 could be the culprit.

Getting Storage Right

Hey Doc, I read the letter in the January issue from a reader who described his "powerful photo/video editing machine" with five WD Black 3TB hard drives in RAID 5, and I cringed. I'm a systems administrator and a performance PC enthusiast, so I'm passionate about performance. But not at the expense of reliability. I suggest that you dissuade people from using RAID 5. It's not a preferred configuration anymore because hard drives are too large to make reconstructing a failed disk's data reliable. There is too great a risk of unrecoverable read errors. RAID 1+0 is much more dependable, and with just one more hard drive, the reader could enjoy great performance and greater peace of mind.

–Kyle Wagner

THE DOCTOR RESPONDS: Thanks for weighing in, Kyle. The Doc admits to running a four-drive RAID 5 array plus hot-spare in his own NAS. But you have him thinking about a change....

The 4K Blues

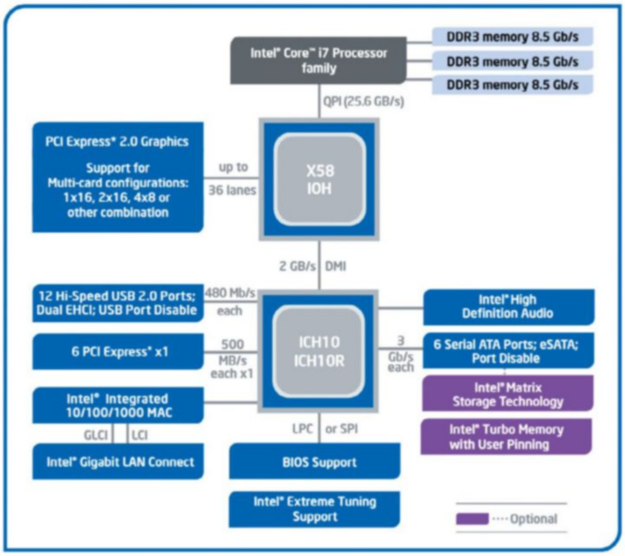
Hi Doc. I want to build a new gaming machine and I have a few requirements, such as an M.2 NVMe-based SSD, water cooling for the CPU and GPU, and a 4K monitor. I'm looking for help in choosing the right video card and monitor. I'd like to stick with one GPU instead of using CrossFire or SLI. I mostly play *World of Warcraft* and *Fallout 4,* though I have one heck of a library on Steam waiting for me. The most demanding title in there is *The Witcher 3,* I believe. Can you offer any suggestions?

–Mike Steinmeyer

THE DOCTOR RESPONDS: The two fastest single-GPU graphics cards—AMD's Radeon R9 Fury X and Nvidia's GeForce GTX 980 Ti (let's ignore the Titan X for now)—do achieve playable frame rates at 3840x2160, but they don't leave much wiggle room. If you're building a new PC with 4K in mind, you'd be far better served by a couple of Radeon R9 Fury or GeForce GTX 980 cards.

Graphics are quite cut and dry; it's much more difficult to recommend a monitor. As of now, there's one 4K display with G-Sync (Acer's XB280HK bprz) and none with FreeSync. By the end of this year, AMD is expecting 2160p120 panels with variable refresh technology. But that's still so far off.

The Doc enjoys gaming on three 2560x1440 displays side by side, yielding a 7680x1440 surface. There are several great gaming-oriented QHD options out there, so perhaps that's an alternative until the 4K segment matures a bit.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Optional

Sure, it's old, but Intel's X58 chipset still has enough PCI Express connectivity to accommodate multiple high-end graphics cards.

To SLI or Not?

Hi Doc. I want to thank you and *Maximum PC* for the content. With the help of this magazine, I've built four PCs and repaired two laptops. In one year.

I'm currently using an EVGA GeForce GTX 960 SSC with 4GB of RAM. I'm planning a Skylake upgrade this year and was wondering, since I'll be swapping out motherboards, should I pick up a second 960 to run in SLI, or upgrade to a GeForce GTX 970? My current specs include an ASRock Z97 Extreme4, Intel's Core i5-4690K, 16GB of Crucial Ballistix DDR3, a WD Black 500GB hard drive, a WD Black 1TB hard drive, and a Thermaltake 600W power supply. **–Eric Buck**

THE DOCTOR RESPONDS: Thanks for reading, Eric—it's good to have you on board. The Doc is hoping he can help take your existing build and mold it into something even more potent.

To begin, your Core i5-4690K is a competent performer, particularly if it's overclocked. Moreover, the Z97 Extreme4 is loaded with modern amenities, and you've equipped it with lots of DDR3 memory. Consider keeping those components to serve as the foundation for a faster gaming PC.

Your most glaring omission is an SSD. Adding solid-state storage will have a bigger impact on your experience than any other upgrade. Drop in at least 256GB. From there, you'll want to think about graphics. Given that you currently own a GeForce GTX 960, the Doc assumes you're gaming at 1920x1080. A second 960 would do wonders for performance at that resolution. Because you had the foresight to snag a model with 4GB of GDDR5, you could step up to a QHD display and still enjoy smooth frame rates. The two cards in SLI would be faster than a GeForce GTX 970. They'd even give the 980 a run for its money.

Two GeForce GTX 960s—specifically with 4GB of memory—make quick work of ultra-quality gaming at 1920x1080, even 2560x1440.

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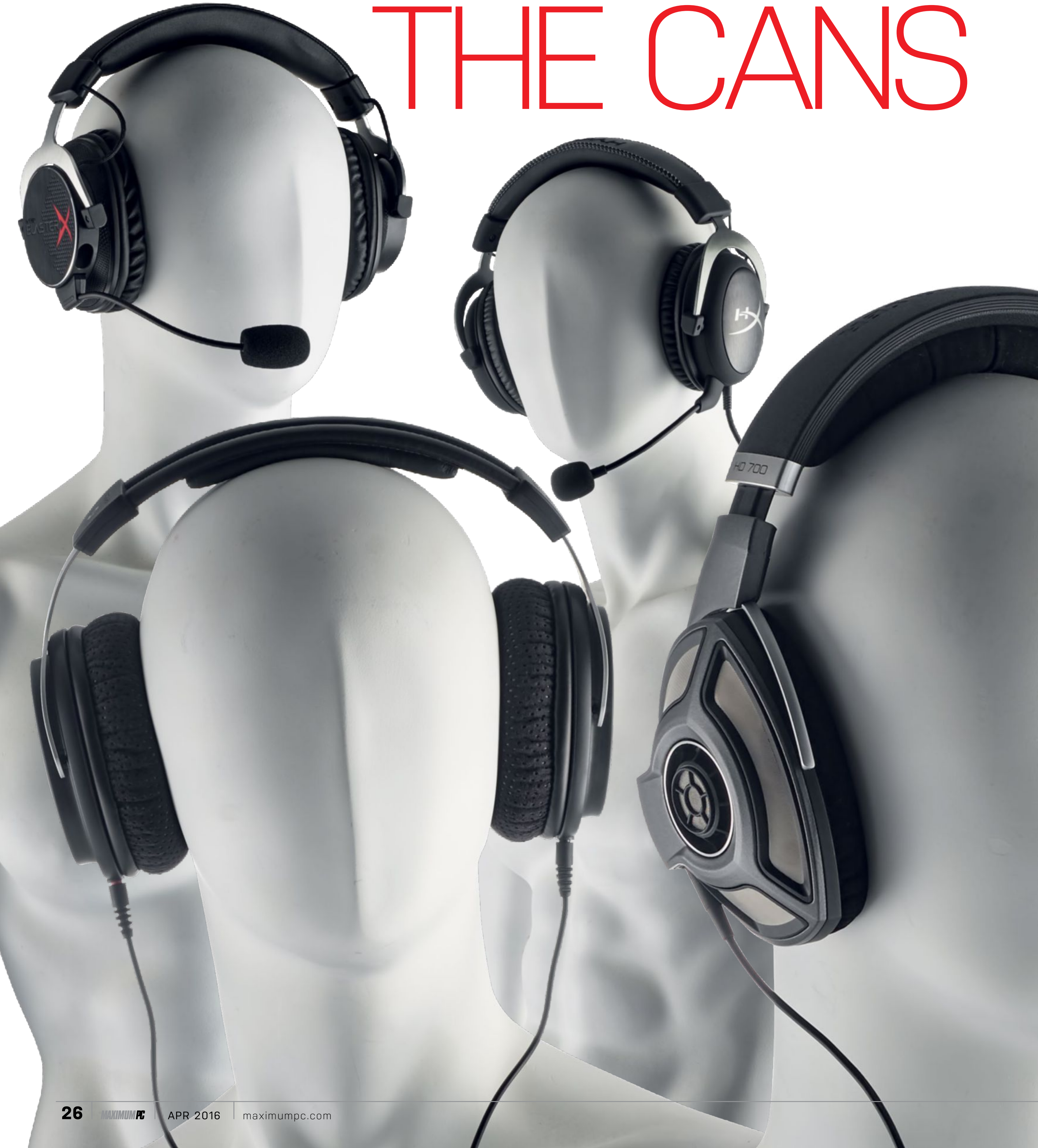
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Finding the perfect audio solution for your PC's media

By Zak Storey & James Russell

Describing audio is incredibly difficult. How do you evoke something that is so subjective? There's no quantitative data here, no numbers or simple conclusions as to what truly sounds better. Indeed, every pair of ears on the planet hears and experiences every song, every noise, every hum, differently from the last. Over the last 50 years, the majority of us has had access to a phenomenal variety of sound. Whether that's music, film, video games, or general noise located outside the reach of our PCs, each of us has experienced these acoustic vibrations differently. And in turn, each of us has developed a unique feel for what we like to listen to.

What we can judge is the quality of sound. Here at *Maximum PC,* we'll be the first to point out how badly audio quality has suffered over the last 20 years. Fortunately for us, long gone are the days of poor-quality MP3 files and sub-par compression, designed to fit 100,000 songs on your iPod. In fact, it's with a sigh of relief that we've at last begun to see a resurgence in the number of people passionate about impeccable audio once again. As more of our community steps away from cheap on-board acoustic solutions and gaming headsets, manufacturers are stepping up their game, improving the quality of their headphone drivers, software decoders, and streaming services. Take Aspiro's Tidal, MSI's Z170A Gaming M9 ACK, and Audio-Technica's ATH-AG1X—all are proud examples of this trend, products designed to take advantage of that desire to listen to something that truly makes the soul sing.

Audio quality is intrinsically connected to three major elements—the holy grail of auditory perfection, if you will: your DAC, your drivers, and your files. Read on to find out how exactly this trinity of sound is put together, and decide whether you should make that final jump to join the ranks of your HRA brothers and sisters.

Audio Affairs

OVER THE LAST five years, the PC enthusiast community has seen a paradigm shift in how it enjoys audio. It hasn't been an instant movement, nor an unsuspecting avalanche gaining momentum as it hurtles down the snow-covered peaks of auditory perception, but a slow trickle. A step away from traditional gaming headsets in favor of high-fidelity audiophile headphones.

Thanks to the advancements we've made in networking and storage capacities, for the first time many of us are opting to forsake the cumbersome ruggedness of MP3s and AACs in favor of lossless or HRA music files instead, notably the FLAC file format. However, although the problem of file size is no longer an issue, if you're not running a suitable digital-to-analog converter, in combination with a dependable pair of headphones, you're not going to benefit from all that extra detail held within the depths of each track.

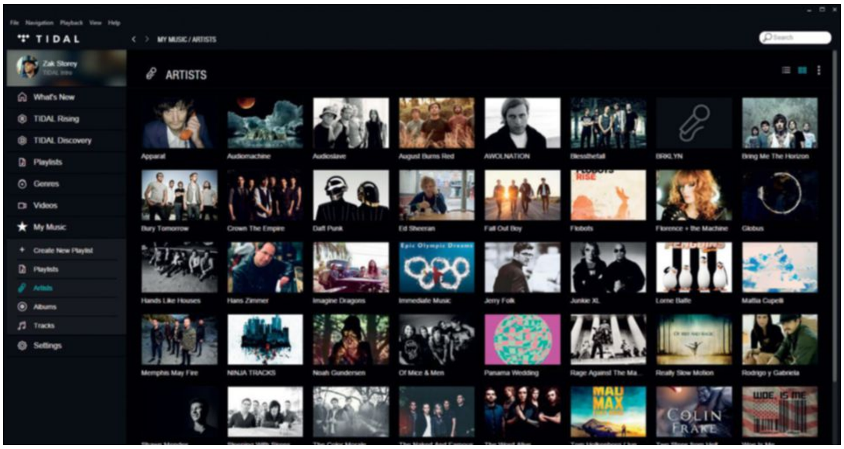
For the gamers amongst us, this tends to lead to one crucial problem. Dropping the headset for a pair of high-fidelity cans leaves you sans microphone. Not good, especially if you are into team-oriented gaming, or just want a quick blast at the weekend with your friends.

Fortunately, the likes of Blue Yeti and Razer quickly jumped to the rescue, providing dedicated microphones for those of us with the budget. And for those without, necessity once again became the mother of invention, and it wasn't long before Antlion came out with a fantastic solution in the form of the ModMic—an affordable, stick-on, headset microphone that you could attach to any of your favorite headphones without a problem.

Two more years, and Audio-Technica, Beyerdynamic, and Sennheiser all had their own lineups of high-fidelity gaming headsets, designed to provide gamers with the audio they deserve, while still catering to their needs. High-quality microphones, an ergonomic and comfortable design, and a slightly bassier sound signature than found in standard headphones, these were the marks of the new and improved gaming headsets.

Innovative yet successful, the ModMic is widely known as the answer to a gaming audiophile's woes.

High-Fidelity Audio & MQA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Rage Against The Ma...
Really Slow Motion
Rodrigo y Gabriela

Tidal is one of the few services to support full FLAC 1,411kbps streaming.

LET'S FACE IT, all this headphone palaver is null and void if you're sitting there listening to 96kbps MP3 files through iTunes. What's really important is the quality of the file you're listening to. Looking back at the original MP3 format, these were generally one-eleventh the size of the files written to CDs for sale. For clarity here, music was usually sampled 44,100 times per second while being recorded. Each sample would take up two bytes of data, and separate samples were taken for the left and right speakers for use in stereo. What this meant was you would end up with a phenomenally large file for each track on a standard CD.

MP3, on the other hand, was a compression format designed to counter this predicament, providing listeners with a "good enough" audio experience, without taking up vast amounts of storage space. To do this, the original sound was compressed using a method known as perceptual coding. Using psychoacoustic models, the algorithm would remove any auditory components that were considered inaudible to humans, or unnecessary, reducing the accuracy of particular parts of the sound within a track. This reduced the overall file size without compromising on audio quality too much. Although this sounds great, in reality it had a bad habit of deleting overlapping audio, and slicing up the upper and lowermost ranges of sound within each track. Guitars, string instruments, and treble-heavy percussion took the greatest hit, creating a sound that was far less punchier than the original.

Depending on how much space you were willing to part with, it was possible to use this lossy data compression at higher or lower bit rates (128kbps being the average), ensuring a higher or lower quality, or resolution. MP3 was succeeded by AAC, or Advanced Audio Coding. This new file format followed the same basic principles as the original lossy codec compression of MP3, while achieving greater sound quality at the same bit-rates, all while maintaining a similar file size. AAC is still around today, and is used in the vast majority of devices and streaming services online, from iTunes to YouTube. The thing to take away from this is that the higher the bit-rate, the greater the resolution of your music, and the larger the file size.

However, these formats are less than ideal if you're trying to replicate every nuance and sound found within the original CD recording. For that you need FLAC, or Free Lossless Audio Codec. As the name suggests, this compression codec has little—if any—acoustic degradation. On top of that, it's open source and isn't held back by any proprietary patents. FLAC provides

users with the ability to copy any CD track at a far greater resolution than before (1,411kbps), the only problem being you have to endure the file size. Although FLAC compresses the data from the original recording by 20 to 40 percent, you're still looking at albums nearing 1GB apiece, depending on the version of FLAC you use.

What's the solution? Well, if you're not interested in storing 400GB of music on your hard drive for your own personal library, Tidal is the obvious bet. A premium subscription will set you back $19.99 a month, but you can take advantage of its massive archive, and stream FLAC files over the internet to your PC and other devices. On top of that, there's one little gem Tidal's about to support just around the corner, which will blow FLAC and all the other formats out of the water: MQA.

KING OF COMPRESSION

Standing for Master Quality Authenticated, MQA is a unique take on file compression. It takes all the information recorded before a track is written to disc, before any preliminary compression is applied, and folds it together instead. Think of it like this: Take a traditional MP3 file. In that file you have peaks and lows across the entire spectrum of recorded sound. The overall height and size of that file is always at a set point, and in that file you're going to have all this extra space left over where there's little to no sound being played at all, or where the song is far quieter than its crescendos. MQA folds all of the extra detail and nuance, which is usually cut out of the original recordings or slaughtered via MP3/AAC compression, and places it into that dead space within the file. This means you end up with a similarly sized file as an AAC, at a quality that far outstrips anything we've ever heard from the likes of FLAC, CD, or even vinyl. The beauty of MQA extends far beyond this. Of course, you'll need a special proprietary decoder to be able to access all of that additional sound, but if you don't have a device with access to one, you'll still get exactly the same quality as you would if you were listening to an HRA FLAC recording, but at a far smaller size.

Fascinating Rhythm
George Gershwin
Standard Collection

The Pioneer XDP-100R may set you back $600 but it does play MQA files.

How Headphone Drivers Work

WHAT ACTUALLY POWERS these marvelous sound wave pushers? It all comes down to three types of driver. Located in each headphone cup, they all work off the same basic principle. Each uses electricity and a diaphragm to compress and decompress the air. Done fast enough, they create a vibrating pressure wave, which your ear drums pick up.

DYNAMIC DRIVERS

By far the most common headphone driver, dynamic drivers operate by utilizing a coil of ultra-thin wire. In short, the electrically charged part containing the necessary data to create the sound is sent through the wrapped coil, which then creates a magnetic field. This in turn reacts with a magnet placed near the center of the driver. This then forces the coil, which is attached to the center of a diaphragm, to rapidly move backward and forward, depending on the strength of the electrical part. This then moves the driver's diaphragm, to which the coil is attached. By doing this in quick succession, the driver then compresses and decompresses the surrounding air, creating the sound waves our ears pick up as noise. It's the simplest technology of the three types, but dynamic drivers provide some of the best bass sounds.

PLANAR MAGNETIC DRIVERS

Less common and often much pricier than their dynamic counterparts, planar magnetic drivers can provide a superior listening experience by reducing the degree of non-linear distortion. Dynamic drivers have a habit of warping sound at higher volumes. Planar magnetic drivers, on the other hand, forsake the single magnetic field and coil of wire in favor of two magnetic fields placed either side of the diaphragm. The diaphragm is also far lighter and finer than its dynamic cousin, and instead of being attached to a wire coil in the center, has a multitude of flat capacitors across its surface. So instead of pushing the charged part directly through the small wire coil to produce the vibrations, it is pushed across the entire diaphragm. Thanks to this increase in surface area, it's possible to replicate sound at higher volumes without losing out as heavily to non-linear distortion, providing a far cleaner and more accurate soundscape.

ELECTROSTATIC DRIVERS

The electrostatic driver is the pinnacle of headphone sophistication. Remember Sennheiser's Orpheus headphones from CES? $55,000 worth of headphones? Yeah, those are what we're talking about. They aren't cheap and they're not portable either. You need to power them through an electrostatic amplifier or energizer, without which they become a very expensive paperweight. The difference? Instead of relying on conductive material to move the diaphragm (whether that's coiled wire or electrical capacitors), the entire diaphragm itself moves. It's a super-fine sheet of electrically charged fabric, measuring mere microns across, fitted between two metal plates, one positively charged and the other negatively charged. This way the entire diaphragm can be pushed or pulled toward either plate, ensuring the headphones produce the vibrations needed to compress the air, creating sound waves with absolutely no discrepancy.

Headphone Impedance & Signal-to-Noise Ratio

TWO OTHER IMPORTANT factors to take note of when looking at headphones are impedance—also known by the figure Z, and measured in ohms—and the signal-to-noise ratio, measured in dB. By and large, impedance is the amount of electrical current necessary to operate your particular headphones. Portable music players, mobile phones, and devices functioning on chemical batteries tend to only operate headphones with an impedance of less than 32ohms. Although you can plug a pair of 300ohm headphones into one of these devices, the headphones themselves would sound incredibly quiet compared to the volume they are capable of producing. Generally speaking, higher impedance headphones are, more often than not, found in music studios and hooked up to a DJ's turntables, because thanks to that higher impedance, they can use more sophisticated and larger driver technologies, ensuring a greater sound scope and clearer signal, as a less intense AC current is used to power the headphone's drivers.

Each type of headphone driver has a natural impedance—think of it as similar to resistance in a DC circuit, except instead of a flat block, impedance actually acts as a resistance to dramatic change in current; this is because we're dealing with an alternating current as opposed to a direct one. What this does is slow the flow of electrons passing through it. In short, the lower the impedance, the faster the current can travel through the cable to the driver. Ultimately, this means that the device you plug your headphones into has to pump a higher current at lower impedance to compensate for that lack of resistance. In turn, this can introduce electrical noise into the process.

Signal-to-noise ratio, on the other hand, is a measurement used to define how much of the noise you want to hear is audible over the noise that is introduced by background electrical signals and other interference. Regardless of how clean you manage to get your audio, you will inevitably always end up hearing a faint crackling at louder volumes. Think of it like useful information on a forum—the first number in the ratio indicates the number of useful posts; the second number indicates the number of trolls (ahh, what it would be to live in such a world). So the higher the SNR, the less audible background noise you're going to hear at higher volumes, and a clearer overall sound you're going to experience.

How we tested

IF YOU'VE BEEN READING *Maximum PC* for any length of time, you'll know that in every supertest we ever work on, we always let you know how we tested the gear. Usually this just involves a little annotation below our benchmarks table, listing what hardware we used and what tests we ran everything through. However, we've already established that audio is an entirely different beast. We could look at base specifications for each headset but, in all honesty, that really doesn't tell you much, and the true nature of audio lies in the listener experience—how the sound feels.

That said, we wanted to ensure we had a fair and balanced test bed for this roundup, so we decided on the following. Firstly, it's analog only—we wanted to ensure that no single company or manufacturer had any unfair advantage thanks to embedded soundcards, USB connections, or other such tomfoolery. Secondly, because this is a test of some of the very best gaming headsets versus some of the strongest staples of hi-fi audio, we decided to run each and every headset through two separate external DACs. For this

Audio-Technica's Thoughts

We talk to Kosumo Miyauchi from Audio-Technica about what makes a great gaming headset

Kosumo Miyauchi, head of consumer product planning at Audio-Technica.

Maximum PC: What was it that made you decide to enter the gaming peripheral market?

Kosumo Miyauchi: Some of our audiophile-grade headphones, such as the ATH-A900X, were popular among gamers but, of course, these models didn't feature a microphone, so we started to design and manufacture dedicated gaming headsets in 2013. This allowed gamers to enjoy the high-quality audio performance of our consumer models but with the in-game communication element.

MPC: What kind of special considerations do you make when it comes to designing a high-fidelity gaming headset? What do you think appeals most to gamers?

KM: We combine our rich heritage of designing consumer headphones, studio monitor headphones, and professional microphones for musicians. Also, we offer the option of open-back and closed-back models, so gamers can choose which design suits their style of gameplay.

MPC: What ideas and technologies have you taken from your existing lineup of hi-fi headphones and implemented into your headset range?

KM: Our gaming headsets are based around our consumer

LEFT: **Although a little more pricey than the X7, the Denon DA-300USB is a stunning piece of audiophile hardware.**
RIGHT: **Creative's gaming sound heritage harks back to before the dawn of the millennium.**

we chose the Denon DA-300USB, a $500 audiophile-grade headphone amplifier and digital-to-analog converter, powered by the Texas Instruments PCM1795 digital-analog converter; and the Creative Sound Blaster X7, $400 of gaming HRA DAC/ADC perfection, powered by the Burr-Brown PCM1794 digital-analog converter. On top of that, where possible we tested each pair of cans with both on-board audio via an Asus Maximus VIII Formula, and plugged into an aging HTC One M7. After all, not everyone runs an external DAC—far be it for us to assume that.

Now that's covered, we need to talk about what we tested our headphones with. The first thing we did was listen to a variety of music. We indulged our ear lobes with a range of different musical genres (see right)—streaming FLAC 1,411kbps files from Tidal. Then it was straight into games—still testing on both DACs—with a combination of *Star Citizen, Project Cars,* and *Call of Duty: Black Ops III,* to gauge how exactly the headphones responded and felt under those scenarios. Ultimately, we're looking at three different categories: comfort, style, and most importantly, overall soundscape.

TRACK TESTING LIST

Genre	Artist	Track Played
Heavy Metal	August Burns Red	*The Eleventh Hour*
Rap Metal	Rage Against The Machine	*Take The Power Back (Remastered)*
Rock	Audioslave	*Cochise*
Punk	Flobots	*One Last Show*
Indie	Ed Sheeran	*Bloodstream*
Pop	Shawn Mendes	*Stitches*
Epic Score	Audiomachine	*Sura*
OST	Hans Zimmer	*Rise*
Instrumental	Rodrigo y Gabriela	*The Soundmaker*
Synthetic	Jerry Folk	*Futura*

on Gaming Headsets

headphone ranges, and feature many characteristics of these models. For example, the 3D Wing Support feature was developed for home audio listeners to provide comfort during long listening sessions. This, of course, is something that applies to gamers during extended gameplay—they don't have to worry about wearing fatigue or ache, so they can focus on their play, performance, and audio.

MPC: Can you tell us a little bit about the design process that you go through for, say, the ATH-AG1X?

KM: The AG1X's design is based on our audiophile-grade Art Monitor series. In order to maintain the high audio quality of these high-resolution headphones, the microphone is designed outside of housing, so that it doesn't adversely affect the acoustic space behind the 53mm large dynamic driver. This enables a smoother movement of the diaphragm, and therefore the sound reproduction maintains its quality.

MPC: Can you tell us a little more about what the Double Air Damping System actually does in your new lineup of gaming headsets?

KM: The DADS structure was developed to extend the frequency range and provide richer bass. The space for air behind the driver is limited, so in order to maximize this, the system contains additional smaller acoustic space inside the housing to optimize airflow. It helps to create better damping than a standard structure, and reproduces deeper bass sounds. DADS is also used in our Art Monitor range, and also our high-end wood-constructed ATH-W1000Z model.

MPC: Certainly for our audience, gaming can be a key hobby alongside the enjoyment of high-fidelity audio—is there any chance you can give us any hints as to what your plans might be next?

KM: The gaming market is huge, competitive, and challenging, but our rich audio heritage means we are able to offer headsets steeped in high-quality audio reproduction for an immersive experience. We know this is a priority for today's gamers, and we will continue to focus on this with future headset models.

ALL ABOUT SOUNDCARDS

Once a vital component of any build, why is the soundcard nowhere to be seen anymore? *By James Russell*

SOUND IS A LOT more complex, mysterious, and cooler than vision. There, it's been said! One unassuming conical speaker can conjure up practically any sound, from a human voice to a 100-piece orchestra, and additional speakers can induce an auditory hologram of a 3D space. But the truly devious thing is that what actually happens when a speaker is operating is actually diabolically simple.

INS AND OUTS OF SOUND

The speaker vibrates, moving only forward and backward, compelled to do so by an electrical current applied to it. The voltage of the electrical signal travels above zero, pulling the speaker cone one way, and then back below zero, pushing it the other way. The exact pattern of those in-out movements over time determines the sound that we hear. A pattern of voltage is turned in a pattern of movement, which compresses and decompresses the air around the speaker in that same pattern. The result: sound.

If you record that voltage signal, you can recreate the sound. This worked brilliantly for decades—the movement of a needle through a groove on vinyl, or a playhead on a reel of tape, recreates the voltage, and therefore the audio signal. But storing this voltage pattern as digital data on a computer requires a different approach: an analog-to-digital converter, or ADC.

CRAMMING AUDIO INTO DATA

Input an audio signal to an ADC, and its voltage is recorded ("sampled") many, many times per second to recreate the waveform digitally (as shown in the diagram opposite).

As you'd imagine, the "resolution" of the recorded/sampled audio wave gets better the more times per second its voltage is captured, and the more possible voltage values that can be recorded. For example, CD-quality audio has a bit depth of 16 (65,536 possible voltage values), and a sample rate of 44.1kHz (44,100 samples taken per second).

Once the data describing the audio waveform is captured and stored, it can be manipulated and processed as any other data—but, of course, there's no point in storing audio data without playing it back.

THE DAC

What goes in must come out, and just as an analog-to-digital converter transforms a voltage to a digital signal, a digital-to-analog converter (DAC) acts as a bridge between the computer and the physical world, reinterpreting a binary signal as an AC electrical signal.

The sampling done by ADCs and the reinterpretation by DACs is where the idealistic audiophile often takes issue: How can an effectively "squared" sampled audio signal be a true likeness of the original, smooth wave?

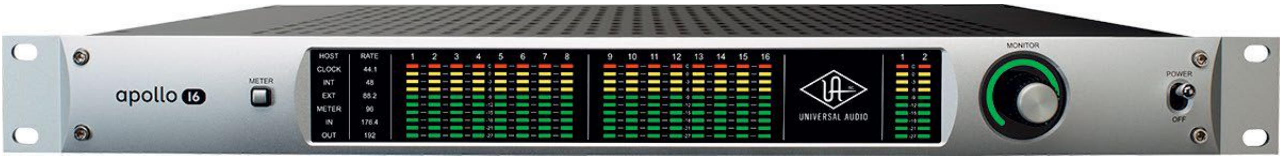
In reality, the DAC applies a filter to the sampled signal in order to smooth the waveform again. In this way, the "squaring" of the signal can be seen as a form of distortion, meaning that, practically, inaudible ultrasonic frequencies have been introduced to carry out the sampling process. By using a filter and removing these frequencies from the signal, the result is a smooth wave, theoretically identical to the original signal that entered the ADC. The same effect can be seen by filtering a square wave in an oscilloscope, as in the video at http://bit.ly/SinSqu.

MODERN SOUNDCARDS

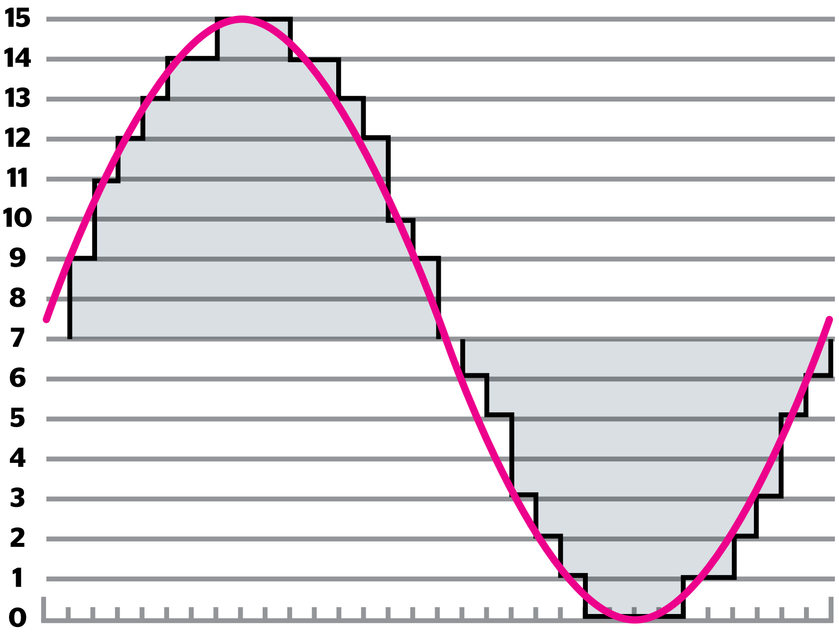
We've come a long way from the days when a soundcard would facilitate unheard-of sounds. Back in the day, the average PC couldn't meet the speeds needed to process decent-quality audio, and a dedicated card was required for anyone who wanted to conjure music or speech from video games. Such Sound Blaster cards didn't actually process that much "audio"—rather, they used synthesis and small sampled recordings to create "realistic" sound.

Nowadays, though, even the most rudimentary setup has enough CPU power and RAM to handle multiple tracks of *actual* audio, and can do so as a background process. The soundcard is no longer necessary as a component in itself, and now takes its place as a permanent installation on the motherboard, or within external hardware, such as a USB headset, where it functions primarily as a DAC to convert digital audio signals into useful output audio ones, and partly as a headphone amplifier, depending on the converter's output level.

Indeed, it wouldn't be hard to believe that many people have never plugged



Universal Audio's Apollo 16 has its own onboard processor.



An analog waveform (pink) being encoded as a 16-bit digital signal (black).

a microphone into their current PC, so have left the onboard ADC dormant for its entire lifetime; the same would be harder to believe for its DAC, though. As it's so frequently used, isn't it a good idea to make sure you've got a good one?

WHAT MAKES A GOOD DAC?

Of course, the resolution afforded by your onboard DAC will have a bearing on its abilities. The larger bit depth and sample rate that the component can handle, the higher quality the audio it can interpret. A worthy DAC should be able to operate at a sample rate of up to 96kHz and a bit depth of 24, exceeding CD quality and reaching a standard at which most professional audio mastering engineers work. 32-bit recording hardware is starting to appear in professional studios, and sample rates of 192kHz have been possible for several years, but it's currently very unlikely that audio files would actually be exported for public consumption—and hence have to be read by your DAC—at this high a resolution anytime soon.

There's also little merit in having a high clock speed if the clock itself doesn't tick on time. The term "jitter" describes inconsistency and aperiodicity in the sample rate. Missing the timing of digital samples literally changes the waveform that is interpreted, and this error is further compounded by errors made at the recording stage by an inferior ADC. Realistically, though, jitter introduced at a high sample rate, such as 96kHz, only changes the audio wave inaudibly, which means that a certain amount of jitter can be practically acceptable.

The quality of the filter that smooths the digitized waveform can make a large difference to a DAC. Its construction from resistors, capacitors, and inductors means that a certain amount of signal delay is involved. If the filter is built from good-quality components, this delay occurs only with high, inaudible frequencies; if not, the response of the highest frequencies in the output audio signal may be unreliable.

QUALITY ON THE CARDS

The same factors that affect all audio components apply to a motherboard's onboard sound components. A low level of thermal/background noise is desirable; the amount of distortion created across a broad range of signals should be as low as possible; and gold audio jacks and ports have absolutely no auditory benefit whatsoever, although they do look cooler.

Today, the closest thing to a soundcard as such is not a removable internal component, but an external audio interface. Standalone external DACs provide a dedicated option for processing output sound, and look great while doing it. Professional input interfaces, on the other hand, are to be found mounted into racks of high-end studios, where they can record up to 16 channels of audio at vast sample rates. Coming full circle, certain high-end music studio interfaces contain onboard processors, which specialize in proprietary audio production tasks, taking the strain off the user's CPU.

Resolution and Data

When pressed to put a number on it, the consensus between manufacturers and associations tends to define high-resolution audio as a signal sampled at 96kHz, with a bit depth of 24 per sample. Sony's Hi-Res Audio standard is starting to proliferate, but even this avoids committing to a strict figure of 24/96.

This is equivalent to the standards at work in professional recording and production studios. Of course, without a rigorously laid-down standard, it's possible for lower-resolution files to be "disguised" in higher-res containers—equivalent to using a high-end camera to take a photograph of a Polaroid picture.

Uncompressed raw files, such as WAV, FLAC, ALAC, AIFF, and DSD, are capable of containing audio at such high resolutions, with the only drawback being the impact on file sizes.

One second of CD-quality audio contains 44,100 16-bit samples—705,600 bits—per channel. A stereo signal brings the total to 1,411,200 bits, or roughly 0.17MB/s. The 24-bit/96kHz Hi-Res or HD standards weigh in at 0.58MB/s, while the cagey über-pro resolution of 32/192 requires 1.54MB/s.

While multi-channel surround-sound is a cinch for today's PCs, there is one bottleneck: Internet transfer rates. The highest quality via a streaming service is currently Tidal's Lossless, at CD-quality 1,411kbps—not enough to necessitate a soundcard with higher specs just yet.

"High-quality" streamed audio is set at about 320kbps. Rather than skimping on sample rate or bit depth, MP3, AAC, and other such containers use compression to remove data that would have been imperceptible if left in.

Hi-Res
AUDIO

Sony's Hi-Res Audio: still not fully codified.

THE MOST
ADVANCED & CUSTOMIZABLE
SYSTEMS

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MILLENNIUM

ORIGIN
HIGH-PERFORMANCE PCS

NVIDIA GEFORCE GTX

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TRION WORLDS

MAXIMUM PC KICK ASS!

PC GAMER EDITOR'S CHOICE ★★★★★

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CORSAIR VOID STEREO GAMING HEADSET

Budget audio but not without sin

AT THIS PRICE, the VOID Stereo is bound to come with some caveats, although we didn't expect quite the degree of plastic and soft fabric that besieged us. For the price, it is understandable. In fact, if it weren't for Kingston offering up the HyperX Cloud IIs, featuring an aluminum and leather design for $10 more, we wouldn't even question it.

Under the Denon DA-300USB, the drivers sounded quite flat, muddiness shone through under heavy bass, and the treble and high mids suffered from a lack of depth. They were OK, average at best. Instrumental music suffered the most, feeling deflated, with less bite, and empty, as though each song had been recorded while the microphone was muffled by a pillow. It was a similar story with orchestral score—there just wasn't enough in the mids. The bass was certainly prominent, but it couldn't make up for the lack of overall soundscape.

With the Creative DAC, the VOIDs still suffered from that lack of upper edge. The bass was more pronounced, as we've come to expect with the X7, but otherwise that's about it. For synthetic dubstep and heavier genres that don't rely on the rising clash of string instruments and treble-based percussion, the VOIDs sounded good. Gaming was enjoyable, too—in fact, the VOIDs excelled in this area. But here inherently lies the problem. You have to want these just for gaming and nothing else. For accurate, deep, acoustical representation, they just fall flat on their face, and that saddens us greatly. After all, none of us really game 100 percent of the time.

Overall, they're still fairly comfortable, and provide a pretty average soundscape. For the price, we would have liked to have seen a better frequency response (maybe to catch some of that missing treble), and use of more premium build materials. After all, this is Corsair, a company that for the last few years has been the king of cool when it comes to aesthetic design.

SPECIFICATIONS

Driver Technology	50mm dynamic
Frequency Response	20Hz–20kHz
Impedance	32 ohms
Connectivity	3.5mm, 4-pole
Weight	12.4 oz

VERDICT 7

Corsair VOID Stereo

⊞ **DARK ABYSS** Comfortable; affordable; quirky design; good for gaming; solid bass signature.

⊟ **EMPTY** Uninspired materials; flat soundscape; low frequency response.

$70, www.corsair.com

KINGSTON HYPERX CLOUD II HEADSET

Superior audio at a fantastic price

COMFORT IS SOMETHING Kingston truly understands—the Cloud IIs are incredibly soft on the old noggin. The closed back design helps isolate you from the rest of the world, and overall they're very lightweight. Long gaming periods are a breeze.

Under the Denon, the Cloud IIs were considerably bassier than our other headsets. The rumble when the bass kicked in was immense, yet it did this without affecting the mids at all. Depth in the overall soundscape was shallower than some of the more premium solutions, but still well rounded enough for everyday listening. In game, the Cloud IIs were crisp and punchy—the added bass signature ensured you felt the explosions in *Call of Duty,* and the roar of the engines as they fired into life in *Project Cars.*

The Creative X7 was a different story. The Cloud II had a bad habit of overpowering the mids just a fraction. It was still incredibly satisfying to listen to the vast majority of musical genres, but if you're into precise classical scores, then these don't cut it. The bass signature was too heavy in contrast to the Denon, and as well as muddying up some of the mids, it felt like the upper end of the treble was stifled. Granted, that is adjustable in Creative's software package.

That said, we can't argue with the fact that these are some of the best value headphones out there. For the price, they're stunning. Overall, they're nicely balanced and well built. Of course, they do lack the sound depth of some of the more premium hi-fi options, but then a lot of those are three to four times the cost. The inclusion of a USB soundcard is a gift to those without an external DAC, and the removable mic is a great feature to see included. On the flip side, they are a little bulky, but otherwise Kingston has really nailed it. If you're after the best value for money headset, the Cloud IIs represent the pinnacle of what you can buy at this price point.

SPECIFICATIONS

Driver Technology	53mm dynamic
Frequency Response	15Hz–25kHz
Impedance	60 ohms
Connectivity	3.5mm, USB
Weight	11.3 oz

VERDICT 9

Kingston HyperX Cloud II

⊞ **HEAVENLY SYMPHONY** Strong sound signature; enhanced bass; great price; swappable earcups; closed back; comfortable.

⊟ **RAINY DAY** Lack of clarity with X7; bulky; gaming-centric.

$80, www.hyperxgaming.com

CREATIVE SOUND BLASTERX H5

Sound, thy name is mud

LET'S START WITH THE GOOD. The Sound BlasterX H5 is one of the comfiest gaming headsets we've ever had the pleasure of using. The reassuring satisfaction you get as it fits gracefully around your lugs is second only to Audio-Technica's newest AG1X. It's not heavy, nor bulky. It just sits right. If only we could stop here.

Right out of the gate, the H5s are incredibly muddy. There's an unbelievable degree of emptiness in the mids and treble. Although the bass is prominent, the overall sound structure is very limited, especially without a DAC. Unfortunately, even with the Denon's fantastic audio tomfoolery, it's still not enough to pull the H5s into auditory good graces. Although they are smoother on this particular DAC than the X7, they just couldn't compete in contrast to any of the other headsets in this group test for crystal-clear audio reproduction.

With Creative's DAC solution, the bass was far more prominent—dubstep, heavy metal, and punk were better, but the clarity needed for instrumental and classical scores just wasn't there. Interestingly, although the bass was quite fierce on these, it didn't manage to drown out the treble. Gaming, on the other hand, was good fun—although the soundscape wasn't very well rounded, for the vast majority of titles, that shouldn't matter too much. This will entirely depend on what games you like playing, of course, but if you enjoy music as much as your games, you might want to take a step back here and opt for something else.

For the price, we'd have loved to have seen a better soundscape. It can be countered somewhat with a dependable DAC or soundcard, but if you're investing that kind of money, you'd probably want to drop some cash into a better pair of headphones anyway. The H5s are comfortable and light, and ergonomically they're strong contenders, but alas, that's just nowhere near as important as solid audio.

SPECIFICATIONS

Driver Technology	50mm dynamic
Frequency Response	20Hz—20kHz
Impedance	32 ohms
Connectivity	3.5mm, 4-pole
Weight	9.4 oz

VERDICT **6**

Creative Sound BlasterX H5

BLASTER Comfortable; strong bass element; good connectivity.

BLASTED Expensive; awful treble/mid; DAC needed for best sound.

$105, www.creative.com

SENNHEISER GAME ONE

Could these possibly be the new kings of gaming audio?

OUT OF THE BOX, the Game One is impeccably comfortable. It's a small design, but not enough to compromise on comfort. Overall, it looks flash, and although constructed primarily from sand-blasted plastic, the Game One feels sturdy and secure. The open-backed design makes it airy, and helps to alleviate some of that sweatiness often associated with closed designs.

With help from the Denon, the Game Ones are surprisingly well rounded. The sound signature is really sharp—reassuringly accurate, in fact. There's absolutely zero mid smothering, and the treble remains sound and true. Bass is definitely there, but it's reassuring, as opposed to vibrating your head off. One problem we can spot is there does seem to be a cut-off on the treble; some of the more audiophile offerings actually provide far crisper trebles, especially at the high end for strings and percussion.

Alongside the X7, the Game Ones are more punchy in the bass department, yet still not too overpowering on mids. These boys just have a really well-rounded soundscape, and it makes them a pleasure to listen to. Perfectly balanced. As far as gaming goes, they do suffer a bit without the extra bass found in most gaming headsets, but if you tweak the EQ just a little, you'll have more than enough power behind your ear drums.

Ultimately, these are a great pair of cans. They're nicely priced, and they're solid for gaming. The crisp, clean soundscape lends itself to those who are looking for almost audiophile-quality drivers without giving up that microphone. That said, they do feel like a very niche product. If you're a true audiophile, there's no doubt you'll opt for a premium pair of Sennheisers, such as the HD700s; if you're a gamer, you'd probably want something with a little more meat to it. But if you do a bit of both, or simply fancy getting your feet wet, the Game Ones are where it's at.

SPECIFICATIONS

Driver Technology	35mm dynamic
Frequency Response	15Hz–28kHz
Impedance	50 ohms
Connectivity	3.5mm, 4-pole
Weight	10.6 oz

VERDICT **8**

Sennheiser Game One

FIRST Crystal-clear soundscape; good price; nice design; strong microphone.

SECOND Weaker bass; upper treble cut off; still plastic.

$180, www.sennheiser.com

LOGITECH G933 ARTEMIS SPECTRUM

We heard you like connectivity

THE G933S REALLY are something else. They're huge—gigantic, in fact. They are comfortable, certainly, but by god, are they big! We simply can't stress that enough. On top of that, they are a little too flexible for our liking. Thanks to that rather skinny headband, and an overall plastic construction, the fear of accidentally snapping these is all too real.

As far as sound quality goes, well this is a tricky one. Plugged in via a 3.5mm jack only, and ensuring the headset is switched off (turning the headset on enables an audio equalizer inside the drivers), brings us in line with exactly what we would expect a gaming headset with these kind of specs to sound like.

With the Denon, the G933s were incredibly bass-heavy, more so than with the balancer switched on. The mids were a little damp, and the overall height of the treble seemed reduced. They certainly pale in contrast to something like the Game Ones we had in for testing. Unless, of course, you switch on the headset, in which case they were just a little subpar.

That said, it was still an enjoyable experience listening to metal or heavier music genres—however, they did have a habit of losing the crispness on the top end. Gaming was good fun as well. The bass was heavy, and the necessary treble and mids required to provide a rich soundscape shone through just enough to illuminate the gunshots, laser fire, and explosions in *Star Citizen.*

Ultimately, the G933 Artemis Spectrum is not meant to be used this way. It's a wireless headset—at worst, USB. With the headset switched on, there's plenty of audio balancing going on internally to ensure a solid soundscape. But for the price, you're limited by it, and you still have to plug them into a DAC to get anywhere near as good a sound quality as some of the other units we tested.

SPECIFICATIONS

Driver Technology	40mm dynamic
Frequency Response	20Hz–20kHz
Impedance	39 ohms
Connectivity	3.5mm, 4-pole, USB, wireless
Weight	13.2 oz

VERDICT 7

Logitech G933 Artemis Spectrum

⊞ **THE HUNT** Great connectivity; onboard balancing; comfortable.

⊟ **THE HUNTED** Fragile; pricey; mids/treble suffer; low frequency response; plastic.

$200, www.gaming.logitech.com

AUDIO-TECHNICA ATH-AG1X

Damn, that's comfortable

AUDIO-TECHNICA'S AG1XS are by far the comfiest headphones we've ever tried. There's very little maneuverability, but in all honesty, you don't need it. The two pads located at the top rest on your head gently and adjust to the fit and shape of your cranium, ensuring the least pressure is placed on top of your skull, and in turn reducing the overall weight involved.

On top of that, despite being a closed back design, the AG1Xs have an wonderfully airy feeling to them. AT's DADS system ensures that there's a thick layer of air surrounding the driver, and it's noticeable.

All in all, they sounded impressive. Under the Denon, they were very bass-heavy, thanks to their gaming heritage and design. Impressively, it didn't overpower the treble, and thanks to that phenomenal frequency response, they managed to keep all of the upper-end treble. Metal, rock, and punk all sounded glorious. Classical music did suffer, mostly because of that bass, but otherwise it wasn't bad. Bass-heavy tracks love these things. In game, the AG1Xs were stunning, with such a broad soundscape and no compromise in the treble and mids, not only could you hear the punch of the explosion, but also the crackle as the sparks flew.

The X7 did lose out on some of that soundscape, but the AG1Xs had a certain warmth about them, an earthy vibe. Ultimately, these little beauties are just really fun to listen to. If you're after perfect sound replication, you might want to opt for some reference studio headphones, but if you just want to enjoy your music, the AG1Xs are the ticket. If it wasn't for the price, these would sell like hotcakes.

The sound quality is stunning, they're beyond comfortable, and the oddly open/closed air design is joyous on the lugs. They don't hug you, yet they isolate noise perfectly. Some of the mid is a little less crisp than we would have liked, but that's an absolutely minor detail in reality.

SPECIFICATIONS

Driver Technology	53mm dynamic
Frequency Response	5Hz—35kHz
Impedance	50 ohms
Connectivity	3.5mm
Weight	11.3 oz

VERDICT 9

Audio-Technica ATH-AG1X

⊞ **DAMN SON** Earthy feel; great design; incredibly comfortable; gaming sounds stunning; music is solid.

⊟ **AWH MAN** Price; mic in way occasionally.

$300, www.audio-technica.com

AUDIO-TECHNICA ATH-M50X

The king of reference audio?

ATH-M50X: WITHOUT DOUBT, the cornerstone of reference audio. If you ask any audiophile out there what headphones you should buy if you're looking to get into the finer delicacies of aural life, they're sure to point you this way. In our experience, we found the M50Xs to be incredibly light and a little bit plasticky—it's only once you start listening to them that you truly begin to understand where exactly that money's gone, and it's straight into the drivers.

With the Denon DA-300USB, we found the M50Xs were quite the bassy number; the overall sound signature was pleasant and warm. Those dynamic drivers provided enough punch without compromising too heavily on the mids. Although the higher treble frequencies were a little cut-off in comparison to some of the other audiophile options in this supertest, they were more than a match for the best gaming headset around. Indeed, when there wasn't the rumble of bass behind you, it's hard to argue that the soundscape on these wasn't perfect. In game, sound was stunningly crisp and not too bass-heavy. *Star Citizen* felt gorgeous as ships darted around above you.

Under the wily Creative X7, the bass was incredible—phenomenally intense. Yet on further inspection, it had a bad habit of knocking out some of the more subtle mids, even drowning out some sound entirely. Great for metal, dubstep, and punk, but not so good for the crystal-clear instrumental or classical score, where clarity of soundscape is key.

These are ultimately the bread and butter of good quality audio, and it shows. They're cheap, affordable, and come with a well-grounded sound signature under the right DAC. For gaming, they're a strong all-rounder. Only downside? Well, there's a little too much plastic for our taste, and they could do with just a smidge of extra range on that soundscape.

SPECIFICATIONS

Driver Technology	45mm dynamic
Frequency Response	15Hz–28kHz
Impedance	38 ohms
Connectivity	6.3mm, 3.5mm
Weight	10 oz

VERDICT 9

Audio-Technica ATH-M50X

+ **MELODIC** Strong soundscape; great price; awesome design; bass-heavy.

− **DISCORD** Bass again; overall range; plastic construction.

$120, www.audio-technica.com

YAMAHA HPH-PRO400

It's not all about looks

THESE ARE, BY FAR, the most striking pair of headphones in this test. Depending on your taste, they're either classy or just not for you. They garnered a lot of talk around the office as they're quite large, and with that bright white color scheme, you certainly do grab a lot of attention. There's very little adjustment available, bar shortening and lengthening—the cups themselves move very little. Because of this, we found them a bit uncomfortable, but as we don't all have large heads, it might be different for you.

Under the Denon, the PRO400s produced a crisp, gorgeous soundscape, filled with an overwhelmingly beautiful bass tone. There's an urgency of warmth to the tracks as you listen to them. All in all, they're incredibly well balanced, although we'd have loved to have heard more range in the mids. Instrumental and classical scores sound light, crisp, and well placed. Something to bear in mind is that these are far bassier than you'd think, but that's what brings the warmth. In contrast to Yamaha's more reference HPH-MT220, they're a little muddy. But that's to be expected—not everyone likes the reference noise. For gaming, these were perfect, providing finely tuned and precise audio. The bass was ideal for the long, drawn-out firefights, although you'd definitely want to pair them with the Creative X7 if gaming is your jam.

Talking of the X7, again the bass was much punchier than before. Thankfully, it didn't compromise the overall quality and range of acoustic accuracy. Classical felt a little too bassy, but was still well rounded at the top end. RATM sounded phenomenal here. That huge bass signature, working in conjunction with the trebles and strong mids, ensured you didn't lose any of the crunch on the guitars.

The HPH-PRO400s really do fall down to personal preference. The style isn't for everyone, we appreciate that, but the sound quality is stunningly good for the price.

SPECIFICATIONS

Driver Technology	50mm dynamic
Frequency Response	20Hz–20kHz
Impedance	38 ohms
Connectivity	6.3mm, 3.5mm
Weight	10.2 oz

VERDICT 8

Yamaha HPH-PRO400

+ **BEAUTIFUL SWAN** Stunning bass; great soundscape; aggressively priced.

− **UGLY DUCKLING** Questionable looks; mids can suffer; not hugely adjustable.

$205, www.usa.yamaha.com

OPPO PM-3 PLANAR MAGNETIC HEADPHONES

The future is planar?

IT'S HARD TO ARGUE against the clarity of planar magnetic drivers, although this newfound technology is admittedly pricey. Short of electrostatic, it provides some of the best audio reproduction on the planet. Oppo has managed to capitalize on this by reducing the size and overall weight of the technology into something far more accessible and stylish for the likes of us.

Concerning sound, we need to discuss something. Straight out of the box, the PM-3s are like a good pair of boots—they need wearing in. You won't get the full soundscape unless you run these things for at least 12 hours. The diaphragm inside moves in a similar fashion to the piston in a combustion engine, and without that work-in time, you're not going to get the same depth (trust us, we tried a worn-in pair and a fresh set). With the Denon, we found the PM-3s had a fantastically well-rounded soundscape; the audio was perfect. It managed to capture and play all the little nuances and errors that give music that human feel. The bass isn't overwhelming—these cans focus more on the tone than the feel of the bass. This doesn't mean there is none, it's just perfectly in tune with the rest of the track. They're perfect for listening to all types of music, and enjoying it.

Under the Creative, they still had a nicely rounded soundscape but with a far greater emphasis on the lower third of the EQ structure. You tended to lose out on a tiny part of the mids, thanks to the additional bass, but they are absolutely perfect for rock and metal—vocals are crisp and clean. In game, they were far meatier here in contrast to the Denon; the hum of an explosion reverberating around your eardrum was a pleasure to experience.

Needless to say, these are pricey. But for $400—god, they're good. They're stylish, comfortable, sound brilliant, and work well regardless of what you plug them into.

SPECIFICATIONS

Driver Technology	55mm planar magnetic
Frequency Response	10Hz–50kHz
Impedance	26 ohms
Connectivity	3.5mm
Weight	11.3 oz

VERDICT

9

K!CK ASS!

Oppo PM-3 Planar Magnetic Headphones

⊞ **LAUNCH** Fantastic soundscape; comfortable; stylish; accurate bass.

⊟ **BETA** Pricey; tonal bass; wear-in time.

$400, www.oppodigital.com

SHURE SRH1540 HEADPHONES

Premium knows no limits

IF THERE'S ONE THING Shure knows, it's audio. The SRH1540s are a stunning piece of engineering. Out of the box, they have an incredible lightness, which is surprising given their size and shape. The feel and build quality is stunning. On top of that, the airy design helps alleviate sweaty ears, and provides (in our opinion) a far better soundscape than more closed-off designs.

Plugged into the Denon DA-300USB, the SRH1540s took our breath away. The bass had a real heavy feel to it. Certainly a lot grander than some other headphones—even the gaming ones—although it wasn't enough to overpower the treble and mids to any great degree. The soundscape is deep and crisp in the songs that can afford it. Rock, metal, and synthetic music suffers very little. That huge bass signature is much needed in games, and it sounds great. Admittedly, it's a medium that can be hard to balance—for instance, we found that some guns and weapons actually sounded a little too sharp; we suffered a fraction of sibilance, depending on the title (and to be fair, this was in *CoD)*.

Under the X7, the SRH1540s were still incredibly bassy, certainly in contrast to the prior DAC. But we're certain we've said that enough at this point. It's good for music listening, but for the sake of getting the right feel, you really either need to tweak the X7 in the software suite, or opt for a more music-oriented solution. In games, we found it just a little too bassy. But the overall soundscape was still very crisp and very rich.

Ultimately, these are some of the best headphones we've tried. If you're just intending to use them at home, they're perfect. Listening to music is a joyous experience, and overall the fact these work straight out of the box to this degree is great. The only downside is the price, but sacrifices need to be made if you're after the best, and unfortunately this is one of them.

SPECIFICATIONS

Driver Technology	40mm dynamic
Frequency Response	5Hz–25kHz
Impedance	46 ohms
Connectivity	3.5mm
Weight	10.1 oz

VERDICT

9

Shure SRH1540 Headphones

⊞ **ANGELIC CHOIR** Blissful sound; strong bass signature; great overall warmth; lightweight; premium.

⊟ **HELL'S LEGIONS** Pricey; might not want to wear outside.

$445, www.shure.com

SENNHEISER HD700

Open-backed annihilation

SENNHEISER'S HD700S are a stunningly crafted, premium pair of open-backed headphones. The build quality is solid, the flexibility limited, but with enough leeway to fit them snugly around your ears. The open-air design adds a fantastic listening experience, giving your ears plenty of room to breathe, and giving music a clarity you usually only get from 2.1 speaker setups.

With the Denon, the soundscape was exceptional, missing little of anything in the mids or treble. The bass was quite prominent but not in a bad way, avoiding rumble for the sake of tone, something more premium headphones seem to lean toward. It wasn't as warm as some other audiophile headphones—possibly due to a small loss in the lower treble/bass—but for metal, rock, or indie, these cans resonated well. Overall, the EQ felt like an inverted bow, peaking in the middle of the bass and the treble, before dropping down at the extremities.

With the Creative X7, the bass signature was enhanced, and we did lose out on the lower mids again. This was a little disheartening, but not something that can't be adjusted in the software suite. In game, they sounded firm and strong. Not having that over-enhanced bass is a strength of the HD700s. It wasn't pumped up too high, and that makes a huge difference. The treble was loud enough to ensure you could hear the rip of the engines in *Project Cars,* really bringing those V8 and V12 engines to life.

In fact, the only real problem was the open-back design. Testing these in the office was a challenge, especially at higher volumes. The amount of sound leakage was astronomical, to the point that it caused a colleague to throw stuff at us in retaliation. Ultimately, the HD700s have a great design, strong soundscape, and premium feel. It just all depends on whether your household can put up with that open-back design.

SPECIFICATIONS

Driver Technology	40mm dynamic
Frequency Response	10Hz–42kHz
Impedance	150 ohms
Connectivity	6.3mm
Weight	9.5 oz

VERDICT 8

Sennheiser HD700

⊞ **HIGH DEFINITION** Premium experience; strong design; comfortable; good soundscape; solid bass.

⊟ **STANDARD DEFINITION** Open-back design; bowed EQ in places.

$450, www.sennheiser.com

BEYERDYNAMIC DT 1770 PRO

The price of perfection

FROM THE GET-GO the DT-1770 Pros scream premium at you. The construction is sublime, the build materials ravishing, and just taking a look at the specs sheet is enough to make your insides quiver. Leather, memory foam, steel—it's all there.

With the Denon, the 1770 Pros are damn near perfect. Listening to any instrumental music is akin to having the musicians in the room with you. That frequency response, coupled with Beyerdynamic's intuitive tesla-dynamic drivers, provides an absolutely pitch-perfect soundscape. There's no compromise on bass, treble, mids, nothing. If anything, the treble is a little firmer than the rest, no doubt to compensate for the phenomenal bass these babies punch out, but there's still no sibilance, and it doesn't unbalance the rest of the audio either. Speaking of the bass, it's the perfect combination of tone and feel. It's hard to keep the grin off your face.

Gaming is a dream. *Star Citizen* was by far the best experience; at high volumes, it fully immerses you in the world. You pay attention to the rattling of the hull, the burst of your engine, and the sound of your pilot's breathing, increasing and decreasing with the Gs he's pulling. You'll even fly better because of it, because it throws you out of this world and into the next.

With Creative's help, it's a different story. The sound is earthier, that signature bass we've come to critique is still prominent, but it's not enough to dampen the Pros' magnificent acoustic response. It's an easier kind of sound to listen to—you could sit there listening for hours, and still enjoy them thoroughly.

Ultimately, the only criticism we have is the price. The entire experience is exceptional but that price is going to stop a lot of people in their tracks. If you ever have the opportunity to listen to these, you really should. They provide some of the smoothest, well rounded, enjoyable audio we've ever had the pleasure of hearing.

SPECIFICATIONS

Driver Technology	45mm dynamic
Frequency Response	5Hz–40kHz
Impedance	250 ohms
Connectivity	6.3mm
Weight	13.7 oz

VERDICT 9

Beyerdynamic DT 1770 Pro

⊞ **PRO** Perfect soundscape; comfortable; build quality; phenomenal bass.

⊟ **CON** Price.

$600, www.beyerdynamic.com

AND THE WINNER IS...

OPPO PM-3 PLANAR MAGNETIC HEADPHONES

PICKING A WINNER here is tricky—there's a lot of great headphones in this roundup, many of them ideal for specific audiences. If we're only talking about audio and build quality, the Beyerdynamic DT 1770 Pro will always win hands down. If we're talking best value for money, however, then Audio-Technica's ATH-M50X steals that spot. Best gaming headset? Definitely the Audio-Technica ATH-AG1X. Best value for money gaming headset? Kingston's HyperX Cloud II. The list goes on and on, but unfortunately we have to settle on one definitive headset. One product to take the place as the best all-rounder. And ultimately, it falls to Oppo to take that mantle upon its broad shoulders.

The Oppo PM-3s are outstanding, the build quality is fantastic, the accessories and packaging incredible, and to be frank, the audio is absolutely astonishing—second only to the DT 1770 Pros. The fact that Oppo has managed to downsize the traditionally heavy and cumbersome planar magnetic drivers, and fit them into a small-form, stylish pair of headphones is nuts. And in the end that's what it comes down to. These headphones fill a multitude of roles, and they do it insanely well. Want to wear them round and about town? Sure. Need to listen to HRA tracks? Done. After a weekend-long gaming session? Yep. It's all there, and that's the point. Essentially, you can use these in almost every environment and be extremely satisfied. Granted, you'll benefit from them most when sitting down at a PC, with a dependable external DAC, but for everyday usage, even on your cell phone, they're still incredibly solid.

Going back to perfect audio a second, Beyerdynamic's DT 1770 Pros are phenomenal. It would be easy to write volumes on how awesome that sound profile is. It speaks to you, brings you to tears, and leaves you sitting in the corner wondering what on earth you've been listening to your whole life. The overall build quality is exceptional, while the added accessories and the fact they can be used for studio and personal use is great.

PRESS PLAY

For gaming, by far the best value for money—and, if we're honest, if this were gaming headsets only, the winner—is the Kingston HyperX Cloud IIs. For $80, they're exceptionally good value, the sound signature is incredibly well balanced for the price, and the fact Kingston has bundled in a miniature soundcard/USB adapter on top of everything else is impressive. If you're looking to have fun gaming, and still enjoy your music, the Cloud IIs are the way to go.

Finally, that brings us to ask what the point is of all this. In short, it all falls back to that same point we spoke about earlier. It's all about high-resolution audio, pumping it through a good DAC, and listening to it with some fantastic headphones. Over the years, we've gained and lost a lot of quality in the hunt for convenience and more impressive recording technologies. And at long last, the name of the game seems to be changing. As hard drive capacities, file formats, and overall network capabilities increase, it appears it's only a matter of time before high-resolution audio is the only audio we listen to. We can't wait for that day to arrive.

> “Oppo has downsized planar magnetic drivers, and fitted them in a small-form, stylish pair of headphones.

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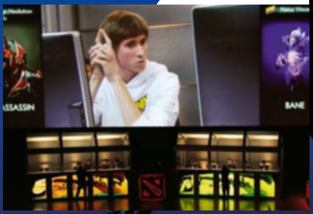

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Intel's range of CPUs has penetrated every nook and cranny of portable PCs. Which do you want?

By Dave James

SKYLAKE GOES MOBILE

Intel's new sixth-gen Core processors represent a departure for the big blue chip-making machine in more ways than one. First of all, it decided to deliver both a tick and a tock in the space of a couple of months. It also figured that it would rather get the desktop chips out the factory door first, then follow them up later with a whole slew of mobile processors, rather than the other way around.

Last summer saw Intel's Broadwell desktop parts finally arrive—with more of a whimper than a bang, it has to be said—only to be followed shortly after by the debut silicon of its brand-new Skylake architecture, again on the desktop. Broadwell was the die-shrink tick, with Skylake being the processor designed to really make use of all the goodness a 14nm production process can offer.

Launching the new Skylake architecture desktop-first may seem a bit odd, given Intel has focused on efficiency since the launch of Sandy Bridge. That push for efficiency means it has taken a mobile-first design approach, and then essentially iterated more powerful versions of the laptop chips to make the standard desktop CPUs.

Intel also has its enthusiast desktop platform, of course, the beefy X99 boards and Haswell-E processors that are packing six or eight cores. But for those, Intel went to the workstation guys making the Xeon server CPUs, stripped out a few features, unlocked the multipliers, and dropped them onto the consumer market.

Intel hasn't specifically designed consumer desktop CPUs for years, and Skylake is no different. Whatever the reason behind holding back the mobile launch, we are now seeing a staggering range of laptop and tablet processors arriving with the sixth-generation Core in swathes of mobile devices across the world.

From configurable TDPs of just 3.5W all the way up to 45W—and even overclockable K-series laptop CPUs—Intel has created the broadest range of mobile chips it has ever made. Which presents a bit of a problem for end users, with all the new naming conventions, and vastly different feature and component sets. Which mobile Skylake processor do we actually want to see as the beating silicon heart of our next device? It's time for some explanations.

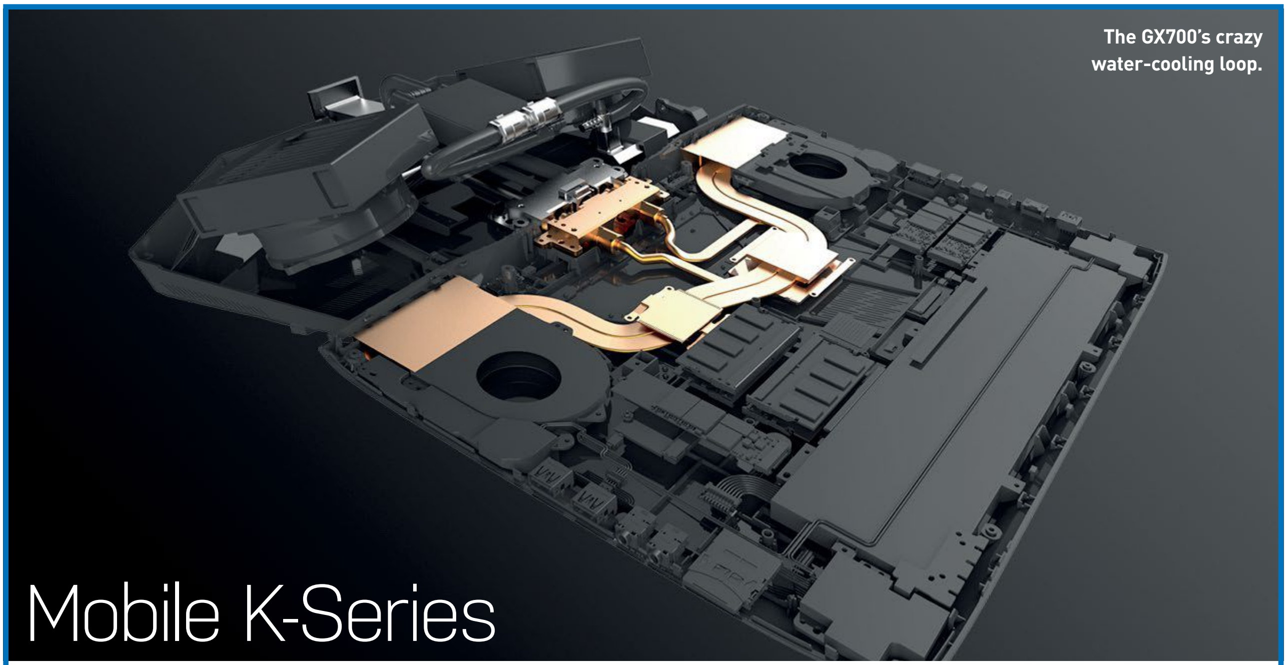
It isn't an exaggeration to say that Intel has created its broadest range of mobile processors ever with the new Skylake silicon. There are nearly 50 different CPUs designed for tablet, 2-in-1, AIO, and laptop devices. It can be overwhelming at first glance, but it's easier to talk about them in three classes, grouped by ascending TDP.

At the bottom of the power-draw spectrum are the Skylake-Y chips at 4.5W, then the Skylake-U series at 15W and 28W, and finally the 45W high-end Skylake-H series. They are designed to be dropped into different devices but all share the same basic Skylake architecture. So they all have the same 14nm sixth-gen Core design at their heart, and the same graphics technology, but are differentiated by feature set, CPU cores/threads, and the number of graphics execution units they contain.

That's an incredibly impressive place to start, if you think about it. Intel has created a Core architecture that is so scalable that it can go from a miniscule 4.5W dual-core part, which will be used in tablets and be passively cooled, all the way up to a powerful 45W quad-core gaming processor that can take on desktop CPUs.

The main aim of an architectural tock, as opposed to the 14nm die-shrink tick of the Broadwell generation, is to drive home the advantages that change in production process can offer, and design the overriding CPU architecture to match it. So Skylake is all about improving the overall performance—seemingly with a focus on really beefing up the graphical performance—while at the same time making it far more efficient.

When it comes to the mobile side of the computing world, that efficiency is king. All-day battery life, generally around 10 hours, is the name of the game, as is advanced stand-by modes that don't drain precious battery power unduly when the machine is not being used. And with the



The GX700's crazy water-cooling loop.

Mobile K-Series

The launch of a new slew of mobile CPUs is rarely that exciting, especially when Intel keeps back the highest end of its silky new Gen9 graphics cores until Krzanich knows when. But there really is one standout processor from the latest list of laptop processors, and it's the first dedicated overclockable mobile CPU we've ever seen.

The Intel Core i7-6820HK is, on the surface, a relatively traditional quad-core, eight-thread 45W processor. Its starting base clock is a modest 2.7GHz, with a maximum Turbo Boost of 3.6GHz, making it not that much different from the rest of the Core i7s in the Skylake-H category. It's got the same 530 series graphics and the same iGPU clock speeds as the others, and the same 8MB L3 cache.

But it just doesn't care what the hell you do with its CPU multiplier, with a healthy disregard for its own safety, just like all the best processors. That means, with the right cooling array, you can push well past that 3.6GHz limit—a quick look at HWBot and you'll see it's rated on there at 4.067GHz right now, though some demos have shown it going as high as 4.2GHz. That ought to give you proper desktop levels of processor performance from a simple 45W mobile part.

Proper cooling is key, or your expensive laptop is going to find a soggy, molten mess where its internal components used to be. We've seen the Core i7-6820HK in MSI's GT72ST (MPC Holiday 2016, p76), but the ASUS GX700 takes cooling to another level. It's a desktop replacement with a detachable water-cooling loop for when you want to go nuts with the clocks.

The Core i7-6820HK, then, is the enthusiast-level CPU to be seen with in your gaming laptop—whether you bother tweaking its multiplier or not.

A Mobile Breakdown

	Skylake-Y	Skylake-U		Skylake-H	
Devices	2-in-1s, tablets, Compute Stick	Thin and light notebooks, portable AIOs, mini PCs		Performance laptops, workstations	
Cores/Threads	2/4	2/4	2/4	2/4, 4/4, 4/8	4/4, 4/8
Graphics	GT1, GT2	GT2, GT3e	GT3e	GT2	GT4e
Package Size	20x16.5mm	42x24mm		42x28mm	
TDP	4.5W	15W	28W	45W	
Chipset	Integrated sixth-generation Core chipset and platform I/O			100 Series chipset	

increasingly visual nature of the computing world, doing all that while also improving the graphical performance of Intel silicon is absolutely vital.

SPEED SHIFT

Skylake brings with it improvements to the clock management of its processors, which effectively replace the old Speed Step feature, and were introduced via a Windows 10 update back in November. By an OS update? Speed Shift both is and isn't a hardware-based feature—in order for it to work, it needed operating system support, which meant it wasn't available at the launch of Skylake's mobile chips. What it does is allow the operating system to completely hand over step changes in processor frequency to the CPU itself. Basically, it allows the processor to govern its own clock speeds, with the goal of making them happen much faster than if it had to jump through OS hoops first.

The whole idea is to improve efficiency by allowing the CPU to quickly ramp up to maximum operating speed when a task is delivered to the processor, which means it can be completed faster, and then return to its idle frequency faster. Intel estimates that it takes around 100ms for its processor to reach maximum frequency without Speed Shift; but with it, an example Skylake chip can jump from 1GHz to 2.5GHz almost instantly, and hit its 3.5GHz maximum speed in just 35ms.

The Skylake mini PCs, with Iris Pro graphics, could be little gaming powerhouses.

All told, Intel believes it can complete some tasks in around 50 percent of the time it would normally take. By hitting top speed faster, it doesn't need to run for as long. That improved efficiency means less drain on the battery, and longer up times all round.

SKYLAKE-Y

That's the codename, but the consumer name is now Core m, and Intel is trying to bring the previously super-confusing nomenclature more in line with its standard just-plain-confusing naming conventions.

Core m is still Intel's premium low-power processor, but it's now rocking a lower-case "m" as opposed to Broadwell's big-boy Core M. The reasons will become clear soon—where the first Core M processors sported names such as Core M 5Y70, Skylake is now aping the Core i3, i5, i7 terminology it uses with its more power-hungry silicon.

As such, we now have Core m3, m5, and m7 to denote the varying levels of performance to expect from the respective power-sipping CPUs. Beneath the lot, though, just to keep things really confusing, is a single Pentium version

Tick-Tock-Tock?

Kaby Lake has established itself as the third generation of 14nm CPUs.

It wouldn't be an article about a new processor launch without a little future-gazing thrown in for good measure, and the next generation, post Skylake, represents an interesting shift in Intel's traditional design cadence.

The tick-tock model has been in use for a decade now, where the tick represents a shrink in production, using existing processor designs, and the tock sees a whole new CPU architecture introduced at that lithography.

That's going to change with the upcoming Kaby Lake line of Intel processors. The seventh generation will essentially be built on the same architecture as Skylake and the same production process, but should include generational performance enhancements, as well as new features to differentiate itself from the previous CPUs.

This lengthening of a production process's lifetime is the result of issues Intel has run into with the physical limits of shrinking its transistors. Initial 14nm yields were low and costs were high, which delayed Broadwell's appearance (hence the Haswell Refresh chips), and the introduction of Kaby Lake will give it time to get the 10nm process right for Cannonlake in 2017.

Cannonlake will keep whatever architectural improvements are introduced with Kaby Lake, but on a new 10nm process. A whole new architecture will follow that, but we haven't heard about its codename yet. The likelihood of that being followed by a 7nm part the following year is looking incredibly slim, then. Chances are that the two-year die-shrink cadence will be a thing of distant memory as it becomes harder and harder to get transistors down further into the single-digit nanometer world. But we're not going to start predicting the death of Moore's Law just yet—we've all been bitten by that in the past.

of the Core m, with basic HD graphics cores and no Turbo mode. There's a "Y" in the codename to help denote the Pentium 4405Y as a Core m part, though.

All the Core m parts carry the same dual-core, quad-thread design, and come with the same Gen9 GT2 graphics core with 28 execution units (EUs) inside, and a 300MHz base frequency. Unlike the rest of the Skylake line, they also only operate with DDR3L memory, as opposed to the DDR4 standard the rest of the Skylake chips interface with.

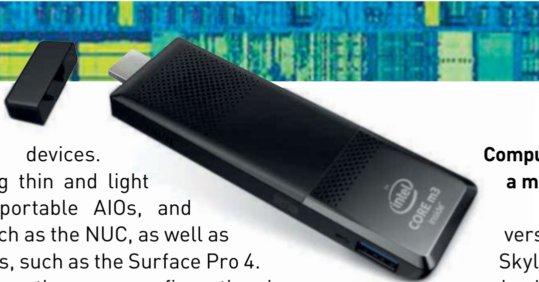
The Core m3-6Y30 has the lowest operating frequency, at just 900MHz, but the key to Core m is the power of its Turbo Boost mode combined with the new Speed Shift feature. The Core m3's single-core Turbo Boost is a healthy 2.2GHz. There is a pair of Core m5 parts, but for all intents and purposes, their only difference is a 100MHz advantage on one of their single-core Turbo Boosts. They both have a base of 1.1GHz, with a Turbo of either 2.7GHz or 2.8GHz, and the GT2 graphics have a Boost clock of 900MHz.

The top Core m7-6Y75 has a base of 1.2GHz and a single-core Turbo clock of 3.1GHz, with a GT2 Turbo clock of 1GHz.

These chips are designed to go into 2-in-1 designs, tablets, and teeny PCs such as the Compute Stick. The difficulty Intel found with the Broadwell Y chips, though, is that while they could potentially go as low as 3.5W or as high as 7W, third-party manufacturers weren't designing the chassis to cope, which ended up hobbling the burst performance of the chips. Intel says it is being more strict on the manufacturer guidelines this time around.

SKYLAKE-U

We're back in more familiar straight Intel Core territory now, with the Skylake-U series of chips. These come in i3, i5, and i7 forms, in two broad categories: 15W and 28W. The *raison d'être* for these parts is to form the basis of the broadest range of



Compute Stick and Core m: a mighty micro machine.

Intel-based devices. We're talking thin and light notebooks, portable AIOs, and mini PCs, such as the NUC, as well as power tablets, such as the Surface Pro 4.

Once more, the core configuration is pretty straightforward with both the 15W and 28W parts restricted to two cores and four threads, no matter their i3, i5, or i7 leanings. On the 15W end of the TDP scale, the i5 and i7 variants have four discrete chips in each category, joined by a single i3. Each is rocking either HD Graphics 520 or Iris Graphics 540.

It's interesting that you'll be able to pick up a mobile Skylake CPU in the cheaper Core i5 bracket, which will still come with the Iris Graphics component. The GT3e part of the Iris Graphics 540 silicon comes with the same 48 EUs as the last generation Iris Pro parts, though only has 64MB of eDRAM, as opposed to the top Broadwell SKU of 128MB eDRAM.

The easy way to tell if a U-series chip has the Iris Graphics is that its name won't contain a double zero. A Core i5-6300U has the base GT2 24 EUs graphics part, while the Core i5-6360U comes with Iris Graphics.

That works with the 28W U-series parts, too, because all four come with Iris Graphics as standard, though they get the slightly higher-tier 550 version. It still has 48 EUs and 64MB of eDRAM, but has a higher TDP and max potential clock speed—though only the top i7 and top i5 chips in this bracket are capable of it. The good news, however, is that there is an i3 version in the 28W lineup, which comes with Iris Graphics, but without the i5 or i7's Turbo Boost tech or the higher GPU clock speed.

You can tell whether it's a higher TDP version of the U-series Skylake CPUs by checking whether there is a "7U" at the end of its model number.

SKYLAKE-H

These are the big-daddy 45W CPUs of the mobile Skylake game. They come with the highest clocks, and represent the only option if you want the full quad-core, eight-thread mobile processing enchilada.

If you were hoping that this would be where you got the complete Iris Pro graphics package, you will be disappointed. All of the Skylake-H parts come with the standard HD Graphics 530 core, with 24 EUs and no eDRAM. Given they're designed for top mobile performance laptops, these are the processors that are going to get matched with beefy discrete graphics cards.

They are also the most familiar for any of us used to dealing with the vagaries of processor names and die configuration. The sole i3 chip, the Core i3-6100H, is a dual-core, four-thread CPU; the two i5 chips are straight quad-core, four-thread parts; and the four i7 processors are the peak quad-core, eight-thread CPUs.

They scale in a fairly linear way in terms of base processor speeds and Turbo Boost clocks, with the i3 running at 2.7GHz, no matter what, right up to the Core i7-6920HQ, with a 2.9GHz base clock and a peak Boost clock of an impressive 3.8GHz. That's going to need some serious cooling.

Speaking of cooling, there is a bit of an anomaly in the ranks of these Core i7 CPUs—the Core i7-6820HK. Yep, a K-series mobile part (see "Mobile K-Series"), the first of its kind, which means it's a deliberately overclockable laptop processor.

Six Years of Processor Graphics

2010	2011	2012	2013	2014	2015
Iron Lake Intel HD Graphics	**Sandy Bridge** Intel HD 3000-2000	**Ivy Bridge** Intel HD 4000-2500	**Haswell** Intel HD 5200-4200	**Broadwell** Intel HD 6200-5500	**Skylake** Intel HD 530
Intel Core Processor	2nd Generation Intel Core Processor	3rd Generation Intel Core Processor	4th Generation Intel Core Processor	5th Generation Intel Core Processor	6th Generation Intel Core Processor
• 32nm		• 22nm		• 14nm	
• DirectX 10.0	• DirectX 10.1	• DirectX 11.0	• DirectX 11.1 • DX Extensions	• DirectX 11.2	• DirectX 12.0
• Up to 10 EUs	• Up to 12 EUs	• Up to 16 EUs	• Up to 40 EUs • EDRAM • Iris Pro, Iris	• Up to 48 EUs • EDRAM • Iris Pro, Iris	• Up to 72 EUs • EDRAM+ • Iris Pro, Iris
43 GFLOPS	**130 GLOPS**	**256 GFLOPS**	**640 GFLOPS**	**768 GFLOPS**	**1152 GFLOPS**

The inexorable rise of integrated graphics power is eating up the low end of discrete GPUs.

WHITHER IRIS PRO?

That's going to be the question on the lips of the graphics-obsessed amongst you reading this far. Even though Intel has officially launched almost 50 shades of mobile Skylake processors, not one of them has come with the peak of its Gen9 graphical prowess.

The GT4e, or Intel Iris Pro Graphics 580, iGPU comes with a mammoth 72 execution units, combined with 128MB of eDRAM, and represents the pinnacle of Intel graphics. It's the Skylake graphics core with the potential for over 1.1TFLOPS of GPU power. That's an Intel CPU with the graphical performance of an Nvidia GTX 950M. That means processor graphics that can actually manage 1080p gaming.

And yet they're still nowhere to be found. Intel has teased that they're to be used on the upcoming Skull Canyon platform, which is due to be a new NUC machine appearing early this year, but other than that, we're clutching at rumors.

Toward the end of January, a reported Intel OEM price list appeared showing an upcoming set of Skylake-H processors all sporting the new Iris Pro cores. There's supposedly a sole quad-core Core i5-6350HQ, running at 2.3GHz, with three further Core i7 models—6770HQ, 6870HQ, and 6970HQ—with base clocks of 2.6GHz, 2.7GHz, and 2.8GHz, respectively.

When these will actually arrive in machines is anyone's guess, though the Skull Canyon timing of Q1 of this year should mean we won't have to wait too long. The prospect of an i5 Iris Pro could make for a relatively powerful 1080p gaming laptop, where the battery doesn't suddenly vanish the instant you fire up a game.

And, while the situation is similar with the desktop chips, where there isn't really a huge number of tangible performance improvements over the last few CPU generations, upgrading on the mobile side makes more sense. The graphics improvements, boosts in efficiency, and Speed Shift power states mean that the mobile parts are still making gains over their progenitors, even if not in straight CPU performance terms.

TECH PORN

MSI GS40 6QE Phantom

WE MAY HAVE played with Intel's Skylake architecture first on the desktop, but as is now the norm with processor developments, it's on mobile where Intel's new silicon really shines. Lower power draw, ever-improving integrated graphics (no, really), and a host of features designed to improve efficiency all make more sense on mobile.

MSI has given mobile Skylake a great showcase in the GS40 6QE Phantom. It isn't just a one-trick pony either, as this capable little notebook boasts healthy graphical grunt for the luscious 1080p screen in the form of Nvidia's GTX 970M. And there's love on the audio side as well, with the ESS Sabre HiFi Audio DAC, Nahimic Virtual Surround Sound, and sound by Dynaudio.

There's certainly a lot to love with this laptop, whether it's the comprehensive storage, the SteelSeries backlit keyboard, or the different performance profiles that help keep the fans under control. No matter if you're looking for a next-gen gaming system, or just a bloody good laptop, the MSI GS40 6QE Phantom checks a lot of the important boxes. –**ALAN DEXTER**

1 GTX 970M

The vibrant 1080p display relies on Nvidia's GTX 970M GPU to provide the raw pixel-pumping power. This mobile GPU is a good match for the 14-inch display, and lays claim to 3GB of GDDR5 to call its own. The latest titles run smoothly on this machine, and look great.

2 Skylake-M

MSI has used one of Intel's new sixth-gen mobile CPUs to provide the raw power for the GS40 6QE Phantom. The quad-core (eight-thread) Core i7-6700HQ is clocked at 2.6GHz, turboing up to 3.5GHz when needed. It's roughly 20 percent faster than the last-gen CPU.

3 NVMe SSD

MSI has employed the classic combo of SSD and hard drive to provide both capacity and speed here. They're both quality drives as well. The 256GB NVMe M.2 SSD boasts a theoretical maximum throughput of 2,200MB/s. The 1TB hard drive is a 7,200rpm model.

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BUY, RENT, DONATE, OR GO FREE?

Electronic Arts shakes up the gaming world with Origin Access, but is it any good? *Dan Griliopoulos* finds out

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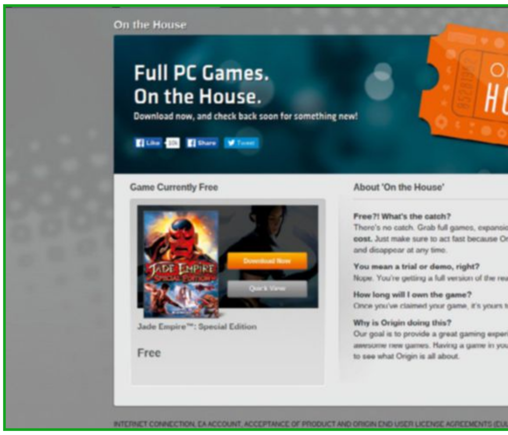
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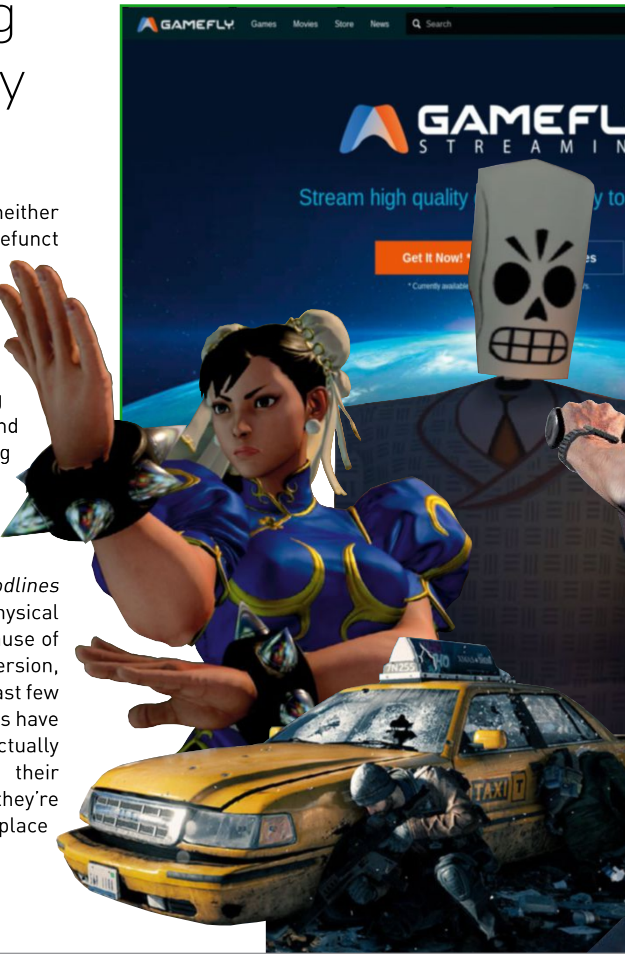
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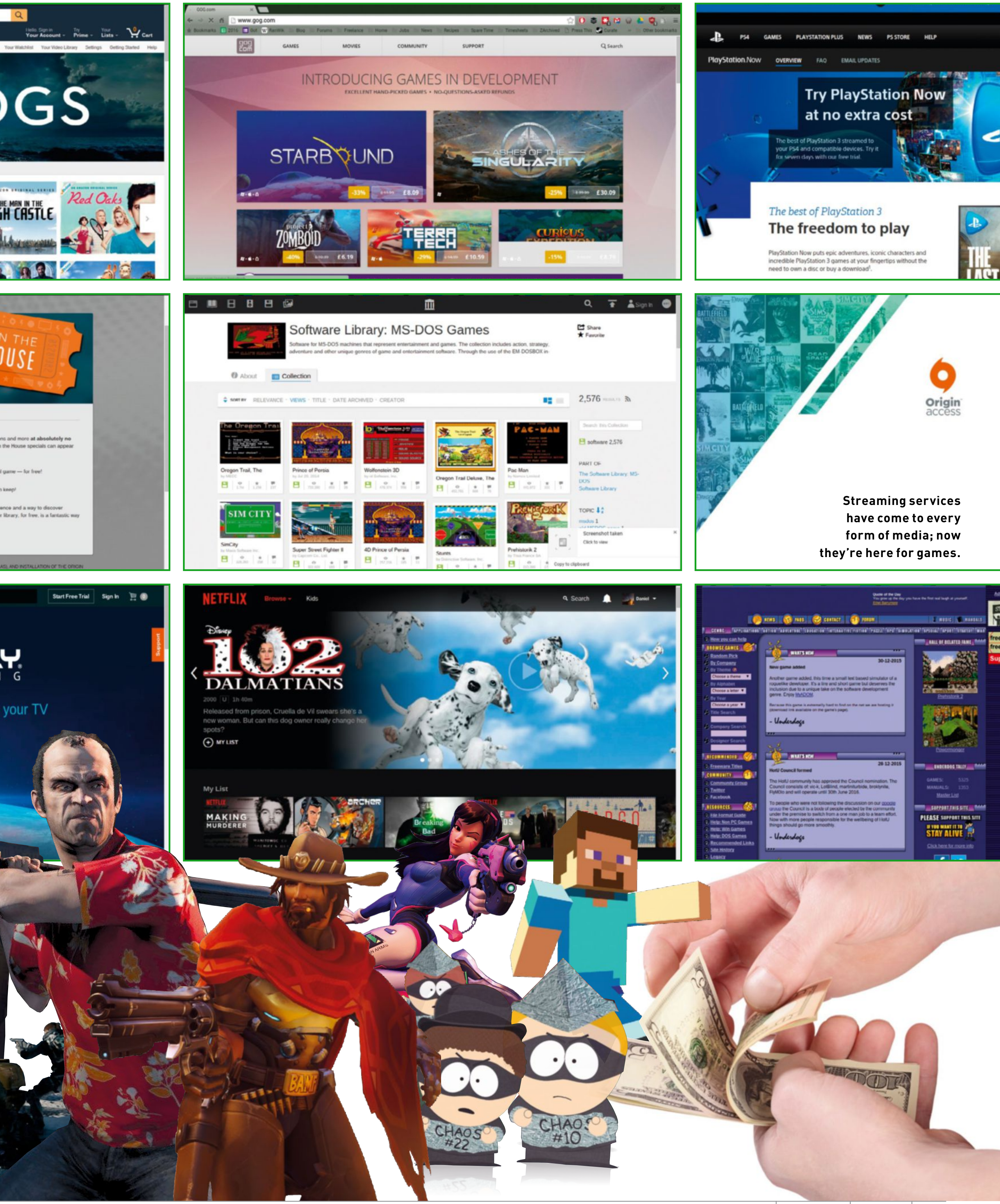
TAXI

How should you get hold of a game? Depending on its age, there might be a hundred ways to get it—from simple torrent or newsgroup piracy (which we don't advocate), to buying a digital download on Steam or GOG, to hunting out a rare physical-world shop and buying it from an actual human being, to forming a crack team of pro-gamers to break into the developer's offices on the day of release, play it extensively on location, then bug out before morning (which doesn't count as piracy, we're fairly sure—just a whole lot of other crimes).

Or you could rent it. This month, EA announced that Origin Access is coming to PC, following the successful run of EA Access on the Xbox 360 and Xbox One. Rental is a strange fish among games—it has a long history on the more commercially minded, copy-protected consoles, but has never really worked with PC games. Yet now several firms are offering game rental and streaming services, most of which are monthly packages like EA's.

But there are still huge problems with renting games these days. Digital products are no guarantee of long-term access—neither the owners of subscriptions to the defunct OnLive streaming service or products bought on the changed Direct2Drive digital download service can access their games anymore, unlike players who bought physical copies of the same games. Many of the game streaming services that were on PC have closed, and their replacements are solely targeting smart TVs—a commercial decision we can't quite understand.

There are also some problems with purely physical copies. Owners of 2004's *Vampire: The Masquerade Bloodlines* (like ourselves) will find that the physical game they own is now unplayable because of unpatched bugs—without the Steam version, we couldn't play it at all. Indeed, in the last few years, most physical copies of PC games have turned into marketing devices, not actually containing any code, which means their supposed advantages vanish. Instead, they're just designed to sit on shelves, to replace books as the wallpaper of our lives.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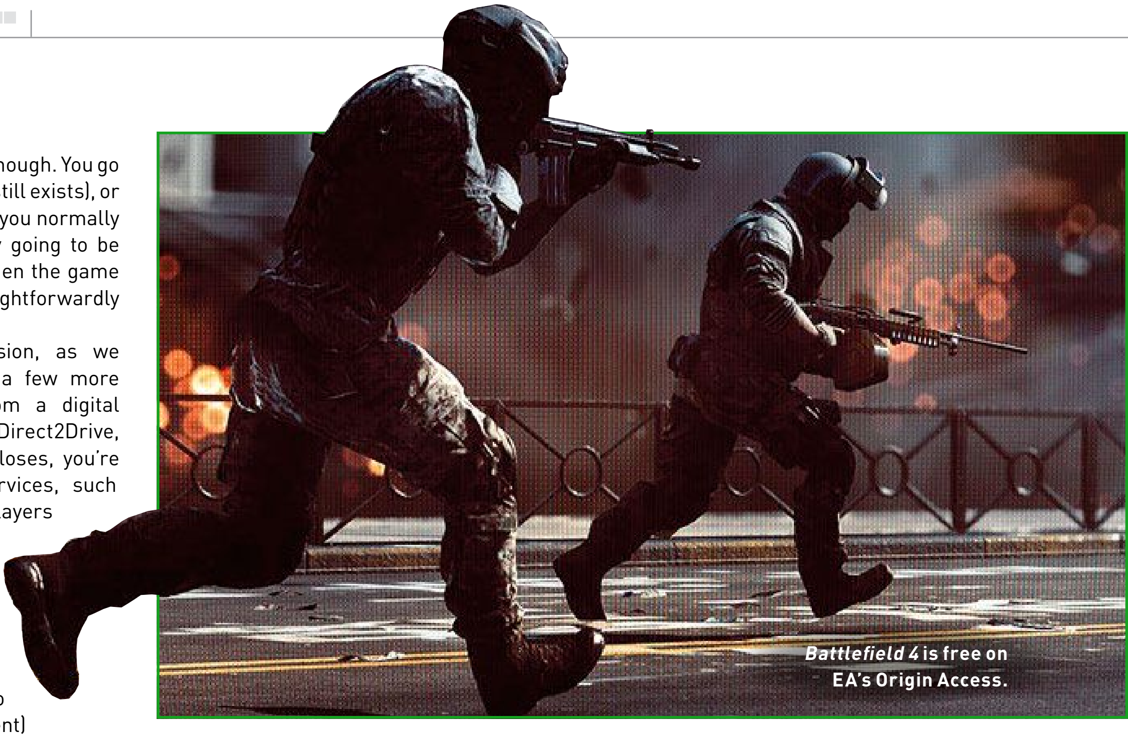
Streaming services have come to every form of media; now they're here for games.



Battlefield 4 is free on EA's Origin Access.

BUYING GAMES

Buying a game seems simple enough. You go into your local game store (if it still exists), or go online to whichever retailer you normally use (let's face it, it's probably going to be Amazon), and just order it. When the game gets to your home, it's straightforwardly there for you to play.

If you buy a digital version, as we mentioned above, there are a few more problems. If you buy it from a digital storefront service—such as Direct2Drive, Steam, or Uplay—that later closes, you're normally screwed. Some services, such as Good Old Games, let players download the entire game and associated manuals, with no DRM, to protect against this kind of thing. Indeed, GOG generally is where you're best placed to go for future-proofing, because it strives to keep its library of (mostly ancient) titles as compatible as possible.

Despite that, Steam is where you're most likely to buy your games. We've covered the problems and boons of Steam many times before, but as a platform for buying games to play, it's difficult to be too critical. With a few clicks and with verified payment systems, you can get a game downloading immediately. If you don't play it, you can arrange a refund equally quickly. (And most games you get through competing services, such as the Humble Bundle, tend to be Steam keys anyway.)

Even the physical versions have problems. These days, they almost always need an Internet connection for the inevitable day one patch. Many physical boxes don't even go that far—they hold no disc except for a Steam key, or if they do, it's the code for a downloader, not the full game.

Collector's editions are nothing new, while at the same time being an innovation. The digital copies allow fans, for a small premium, to get improved versions of their games—often with exclusive content that makes the game easier (health potions or armor, for example) or more fun. The physical copies come with all sorts of goodies, from a slightly shinier box to fully functioning night-vision goggles with *Call of Duty: Modern Warfare 2 Prestige Edition*, or a rubber facehugger with *Alien Vs. Predator Hunter Edition*. (Be warned, though, if you're buying these, that they're considered as collectibles. As soon as you open the packaging, the resale value plummets.)

Remember also that by buying a physical copy, you're giving a lot less money to the developer. To get into one of these shops, a developer needs a publisher. The shop itself takes a cut—and they can't increase the price to do that, because they're competing with online purchases. The distributor takes a cut, too, for the cost of shipping. A publisher takes a large chunk of the game's remaining revenue for packaging and marketing, and passes along a small amount to the developer. Where Steam takes 30 percent, a developer would be lucky to end up with 10 percent of a physical sale.

Not that it matters, as most games sold this way are from the big publishers, who wholly own their developers, which means the creative individuals might get a bonus at most—if the game sells and/or scores well. Most indie games never become physical games, so it's not a big worry for them.

ABANDONWARE

Of course, for some older games, you don't even need to buy them. The law on abandonware is clear; it is pretty straightforwardly illegal to download games that are unsupported but still owned by a viable company. However, if the company no longer exists, and no company has bought the rights, it's fine to download. Similarly, if a company or creator has made their game available for free (like EA's On The House program, for its older titles) or as shareware, you can download that legally, as long as it's still available for free—if they take it down, you've missed your chance.

Sites such as Abandonia.com and Home of the Underdogs walk this thin line between legality by uploading the original code for many older games, and simply taking them down if they receive any legal notifications. Abandonia has been doing this for over 16 years now. HOTU has games dating from 1979's mediocre *Computer Quarterback* and *Mychess*, all the way up to 2005's excellent *Mount & Blade* and *The Ur-Quan Masters*, while Abandonia has the original 1978 *Space Invaders* and 1977 adventure games, up to 2004's *Maniac Mansion Deluxe*.

It's notable that both the Library of Congress and the Internet Archive (http://archive.org) have sought to preserve older games and vintage software. The Internet Archive has uniquely received an exclusion from the US DMCA, which allows it to bypass copy protection for this purpose. Though these games are not available to download, you can play many of them on the Archive's website at http://tinyurl.com/kngkj4w.

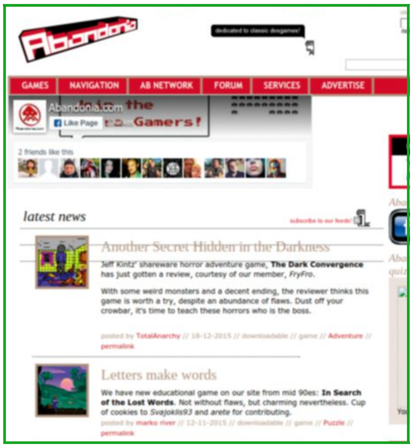
DIRECT TO DEV

Another good tip for indie games you're looking forward to, such as *Manifold Garden*

Be warned, though—they're considered as collectibles. As soon as you open the packaging, the resale value plummets.

Buying the *Modern Warfare II Prestige Edition* is still the best way to get cheap night-vision goggles.

Fancy a facehugger? It's yours, with the right edition of *Alien Vs. Predator.*



latest news

Another Secret Hidden in the Darkness

Jeff Kintz' shareware horror adventure game, **The Dark Convergence** has just gotten a review, courtesy of our member, *FryFro*.

With some weird monsters and a decent ending, the reviewer thinks this game is worth a try, despite an abundance of flaws. Dust off your crowbar, it's time to teach these horrors who is the boss.

posted by TotalAnarchy // 18-12-2015 // downloadable // game // Adventure // permalink

Letters make words

We have new educational game on our site from mid 90es: **In Search of the Lost Words**. Not without flaws, but charming nevertheless. Cup of cookies to *Svajoklis93* and *arete* for contributing.

posted by marko river // 12-11-2015 // downloadable // game // Puzzle // permalink

The legality of abandonware sites such as Abandonia is questionable.

or *Fantastic Contraption,* is to crowdfund them. The lower tiers tend to sell the game ahead of time at a very high discount—so high, it probably won't reach it again until a Steam sale or Humble Bundle several years down the line. Obviously, some kickstarts fail, but the saving you make on every kickstarted game outweighs that gamble, in our humble opinion.

Or you could just go straight to the developer's website, where modern indies often give discounts if you buy earlier in the development process. For example, *Return of the Obra Dinn* is the next game from Lucas Pope, the highly talented and reliable creator of *Papers, Please. Obra Dinn* will almost certainly be brilliant, and Pope is offering an early developer version of it for free. *Cogmind,* by contrast, though it looks like a fascinating science-fiction roguelike, is from a developer we've not heard of—and it's offering the alpha of the game for $30. We're happy to wait for the latter, while we'll happily play the former—but that's down to our appetite for gambling and limited free time, which might differ from yours.

PHYSICAL RENTAL

Physical rental used to be a big market, from cornershop chains such as Blockbuster, who had copied the model from the old TV rental model. For a tenth of the game's cost, you could rent it for enough time to complete it, then return it. It made economic sense for the chain—which could make the value of the game back and more—and for the consumer, who paid much less for a new game. It was a disaster for the game's company, though, which would lose multiple sales on every rented game.

This even affected certain game companies' behavior, especially in conjunction with sales lost to piracy. They had to come up with tactics that meant that players could only use a physical game

THE BIGGEST-EARNING PC GAMES OF 2015

What makes the most money on PC?

GAME		INCOME
LEAGUE OF LEGENDS	Tencent and Riot's free-to-play co-operative strategy game is number one again.	**$1.628 billion**
CROSSFIRE	SmileGate's online FPS is huge in South Korea but mostly unheard of here in the West.	**$1.110 billion**
DUNGEON FIGHTER ONLINE	An online arcade fighter made by Neople, which is huge in China.	**$1.052 billion**
WORLD OF WARCRAFT	Blizzard's fantasy MMO is over 10 years old and still going strong.	**$814 million**
WORLD OF TANKS	Wargaming's online tank combat is keeping the players coming back.	**$446 million**
LINEAGE	Hard to believe, but NCSOFT's boring fantasy MMO is still making money in Asia.	**$339 million**
MAPLESTORY	Nexon's side-scrolling MMO RPG is big in its home territory of Korea.	**$253 million**
DOTA 2	Valve's attempt to dethrone *League of Legends* is failing—but not badly.	**$238 million**
COUNTER-STRIKE: GLOBAL OFFENSIVE	And Valve's classic online FPS still pulls in the western shooters.	**$221 million**
GRAND THEFT AUTO V	Finally, having been released on PC, Rockstar's misanthropic open-world game is the only single-player title in this list.	**$205 million**

SOURCE: SUPERDATA

The Sims 4 is on Origin Access, without its DLC.

once, or would lose out. For example, EA's *Dragon Age* game came with a one-use code for a downloadable character—a golem—that had a unique quest chain. This soon became standard industry practice, so much so that no one today even blinks at bundled DLC on the first day of a game's release. It also allowed the companies to start selling differentiated digital versions of their games, enabling them to charge more money to a game's superfans—something we'll come back to later.

However, physical rental has pretty much died. For example, Lovefilm (now Amazon Prime Video) dropped its physical rental system in many territories back in 2013. In the United States, the much larger population helped these firms to continue thriving, but even so, they've been in trouble. Blockbuster has gone from 9,000 stores in 2004 to 1,700 stores in 2011, down to 50 franchise stores in the most obscure corners of America. By contrast, the online physical rental stores such as GameFly supply physical games for almost all consoles, from $16 for one game a month, to $37 for four games a month.

You might notice we've not mentioned PC games in any of that, for obvious reasons. Physical rental was never popular for PC games because either the software worked against multiple installations or it didn't. If the software came with serial keys with online activation, then that was a one-time install—useless for rental. If it didn't, then players never needed to uninstall the games—so rental turned into pirated ownership every time. There were undoubtedly solutions—an online tracker that deactivated any existing installations, much like Steam locks down accounts to a single computer at a time—but with the already angry arguments about privacy and player-tracking over Digital Rights Management software, it was never worth any game company getting involved.

DIGITAL RENTAL

One form of digital rental is called cloud gaming or streaming, and the previous market leaders in this model of digital rental were OnLive and Gaikai. The former worked well, and allowed easy streaming to any device—but lost money month after month, and closed ignominiously, unable to find a buyer. The latter showed a great proof of concept by embedding streamed games in adverts on websites—but was bought out by Sony, and now works solely as its PlayStation Now game streaming service.

Other streaming services seem to have focused their efforts on acting as business solutions, allowing game developers to stream their hardware-intensive games to users without large downloads or high-spec machines. Kalydo, for example, is used extensively by F2P game companies such as Wargaming.net, GameForge, and Gamigo.

GameFly is the only company we can find currently that operates a reasonably complete PC game digital rental service, through streaming from the cloud. However, it's only available internationally on Samsung smart TVs, and has an extremely limited number of titles, with a bizarre way of packaging them. GameNow offers an even smaller number of titles, and is only available on LG smart TVs and Google TVs. Similarly, PlayStation Now has a huge range of old PlayStation 3

THE STATE OF INTERNET PIRACY

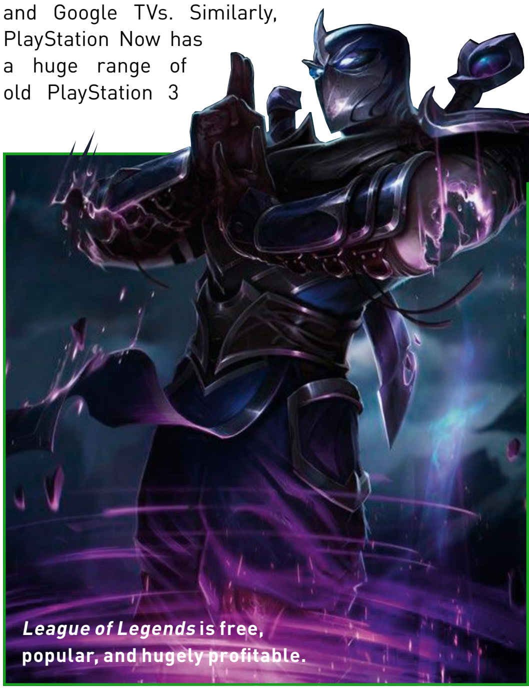
Does piracy cost the gaming industry big bucks?

If you read the music or film industry trade press, piracy is still rampant. "Why else would no one be buying music anymore?" they ask, as they thumb open Spotify on their phone. However, what of the pirate sites themselves? How easy is it to get a pirated game these days?

Really rather easy. The big obstacles to piracy aren't getting the product or getting past copy protection; most big PC games are cracked and uploaded pretty quickly still, and a quick Google normally throws up a few thousand hits.

No, the obstacles are often technical; you have to jump through many hoops to install the title, which might leave your computer open to worms or viruses. Often, there's a virus in a pirated file, just as a bonus—botnets don't build themselves, you know. So serious pirates tend to join subscription-based or invite-only communities for safety.

That means you really have to be committed to pirating a game to do it these days. And that means you're also highly unlikely to be willing to pay for it anyway, so logically, you're probably not a lost sale. Whatever the MPAA says.



League of Legends is free, popular, and hugely profitable.

The latest *FIFA* game is on Origin Access, which for some people could be worth it by itself.

games, but only works on Sony consoles (such as the PS4 and Vita), and Sony or Samsung smart televisions. And all of these packages are subscription-based, with Sony's being very generous and having lots of games, and GameNow's having very few.

The biggest problem for us is that none of these systems works on PC anymore. If you want to stream games to your PC, you're out of luck.

PUBLISHER PLATFORMS

The only other viable systems for digital rental are the publisher platforms—that is, EA's Origin, Valve's Steam, Ubisoft's Uplay, and Blizzard's Battle.net. They're really shell services, like Adobe's Creative Cloud subscription service, which allow users to select from a handful of applications for download, and use them for a monthly fee, then restricting access to those applications if your subscription is canceled.

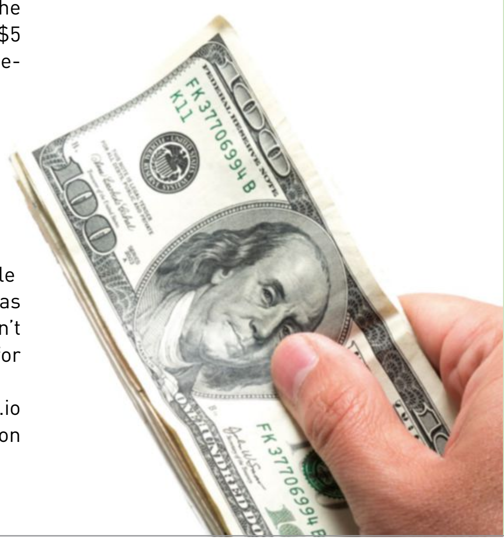
EA's steps toward making Origin a rental platform seem to be along this line, but they're only small steps, which is why the company is keeping the cost so low—just $5 for access to a middle-sized array of middle-aged games.

Although Creative Cloud is a good model, the ultimate goal is something closer to Netflix—a streaming service with a low monthly subscription rate and a huge catalog. None of the major publishers can do that, because they don't have a big enough range of games—while the EA games are relatively recent (such as *Dragon Age: Inquisition)*, the firm doesn't have a huge array to offer. Moreover, DLC for these games is often still an extra cost.

Only Steam, GOG, and possibly Itch.io have access to a large enough selection of games to make this viable. Valve's focus seems to be very much elsewhere at the moment, with forays into PC building, VR, and in-home streaming. GOG still mostly deals with older games, but is the likeliest company with the relationships to make this work—if not the clout. And Itch.io only supplies the most independent indie games. Simply put, a wider rental market seems unlikely—at the moment.

INTO THE FUTURE...

EA's experiment will be good for a small number of us, but it doesn't supply the giant smorgasbord of mid-ranked and older games that Netflix brings to the movie and TV scene. Ideally, a streaming firm with good licensing relationships will spot this niche and step into the space—if the game companies think it makes sense, which is an entirely different question. For the moment, however, it looks as though most of us will continue to buy games digitally as we have always done. ⏻



THE BEST OF THE FREE GAMES

What to play if you don't want to splash the cash

GAME	
SHADOW WARRIOR 1997	This classic hack-and-slash FPS is available for free on Steam. It's extremely cathartic and a nice warm-up for the modern version.
LEAGUE OF LEGENDS	The community might be toxic, and the learning curve like a cliff face, but once you get into it, you'll never get out.
TEAM FORTRESS 2	Valve's groundbreaking team FPS went free years ago, and now has a huge number of modes and maps.
HEARTHSTONE	Blizzard's collectible card game is charming, huge, and mostly free-to-play—you can pay money to get packs, enter the arena, or unlock single-player dungeons.
PATH OF EXILE	Essentially, a really good *Diablo II* clone (that is, third-person, single-player, loot-oriented hack-and-slash), which is totally free.
PLANETSIDE 2	The biggest battles take place between tanks, jets, and infantry in this huge MMOFPS. Nothing else is like it.
WORLD OF TANKS	A huge money-earner, Wargaming's PvP team tank sim is jolly good fun to play around with.
SPELUNKY	This cutesy mine-exploration roguelike platformer is on every system now, but the original freeware game can be easily found online.
STAR WARS: THE OLD REPUBLIC	EA-Bioware's ambitious MMORPG didn't quite take off with a bang, but it's still the best way to explore the *Star Wars* universe—and now it's totally free.
FALLEN LONDON	A gothic multiplayer text adventure set in a version of London that's sunk into hell. What's not to like? This is free, but the superior spin-off *Sunless Sea* isn't.

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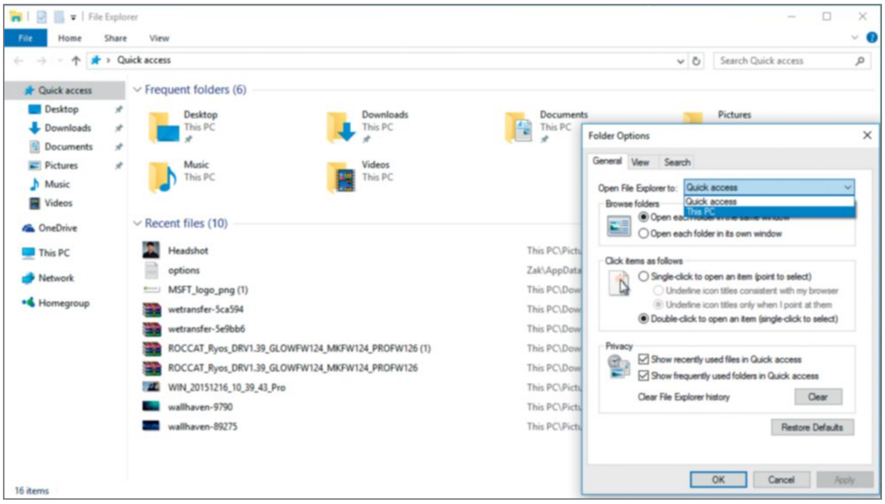
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Cancel
Apply

Open File Explorer to: Quick access
Quick access
This PC

Browse folders
● Open each folder in the same window
○ Open each folder in its own window

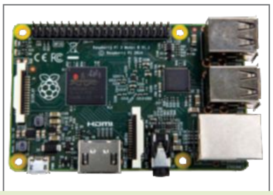
Click items as follows
○ Single-click to open an item (point to select)
○ Underline icon titles consistent with my browser
● Underline icon titles only when I point at them
● Double-click to open an item (single-click to select)

Privacy
☑ Show recently used files in Quick access
☑ Show frequently used folders in Quick access
Clear File Explorer history Clear
Restore Defaults

REMOVE QUICK ACCESS

There's a lot to love and a lot to question in Windows 10. Despite the changes to the "Start" menu, the introduction of Cortana, and concerns over privacy, there's nothing that gets our goat more than the changes to File Explorer. OK, that might be an exaggeration, but it's still annoying. If you're sick of the new "Quick Access" tab, open a new File Explorer, click the "View" tab, select "Options" at the top-right, select the drop-down box where it says "Open File Explorer to," and select "This PC."

MAKE – USE – CREATE



64
Use a Raspberry Pi as a wireless print server

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Improve workflow with our advanced Lightroom tips

72
Build an Oculus Rift-ready VR gaming rig

ZAK STOREY
STAFF WRITER

THE PERFECT STREAM

This issue has been particularly interesting for me because I've been able to pursue one of my greatest passions: high-fidelity audio. The thing is, digital music is a holy trinity of circumstance. It relies on three major factors: the quality of the drivers, the quality of the hardware processing the digital signals, and the quality of the music files you're listening to. This brings us to a bit of a conundrum, and it rests in that last factor. Most of us have a vast library of music littered over our hard drives, gathered throughout our computing lives.

The problem resides in which media service we should use in this modern age of digital streaming. Finding the perfect service can be troublesome. If you want the best quality, Tidal is your answer. Although the premium subscription comes with a hefty price tag, the quality is second to none, and with MQA streaming promised next year, it's definitely one to watch. Choose Spotify, on the other hand, and you pay half the cost for half the quality but a far heftier library.

At this point, it all links back to that holy trinity of sound. If you don't have the right headphones and dependable audio processing, you're unlikely to notice the difference between FLAC and MP3, making Tidal's premium service seem ridiculous. What's the answer? Luckily, these services have free trials. Try them, see if you can tell the difference, and go from there.

↘ submit your How To project idea to: comments@maximumpc.com

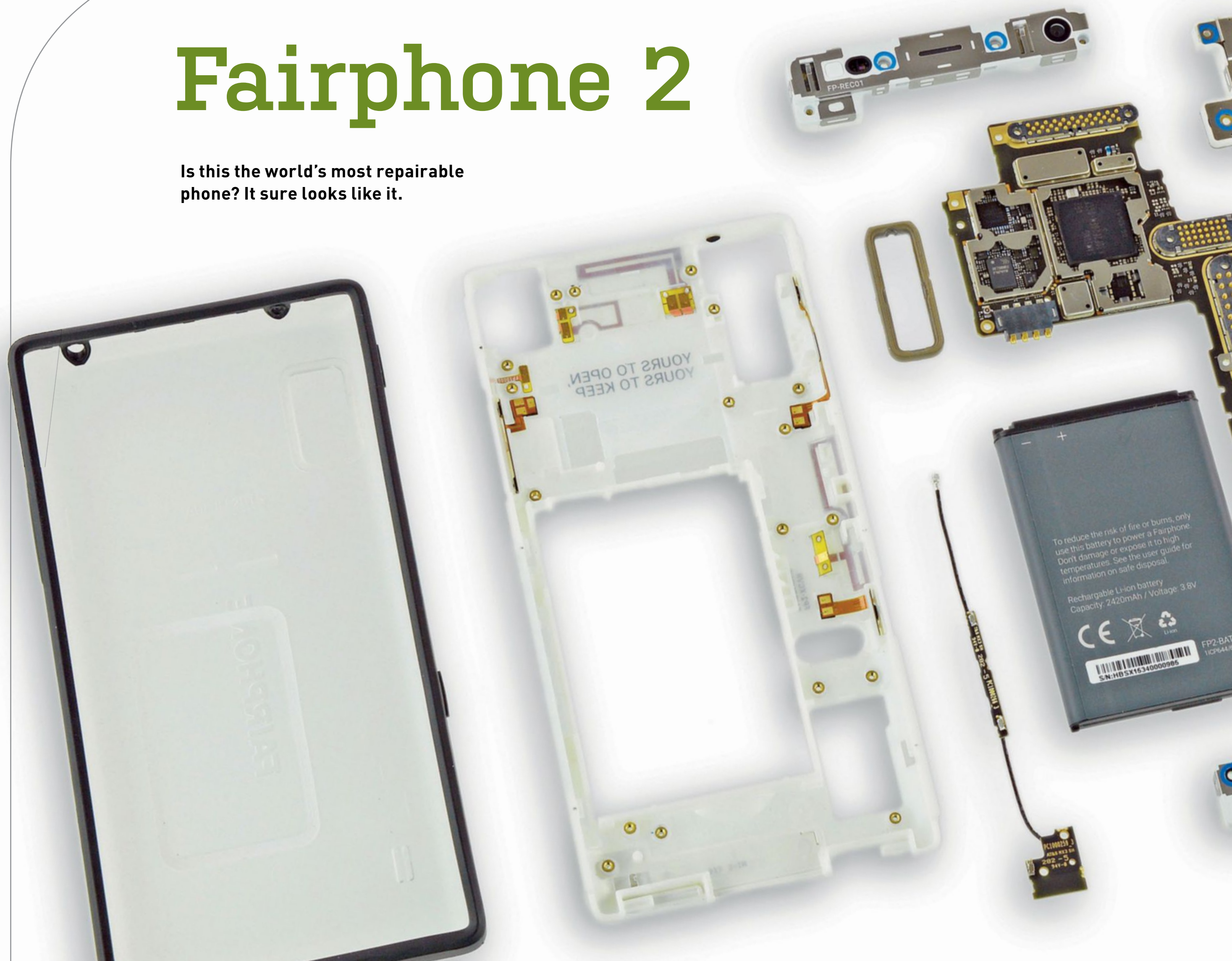
IFIXIT presents:

AUTOPSY

THIS MONTH WE DISSECT...

Fairphone 2

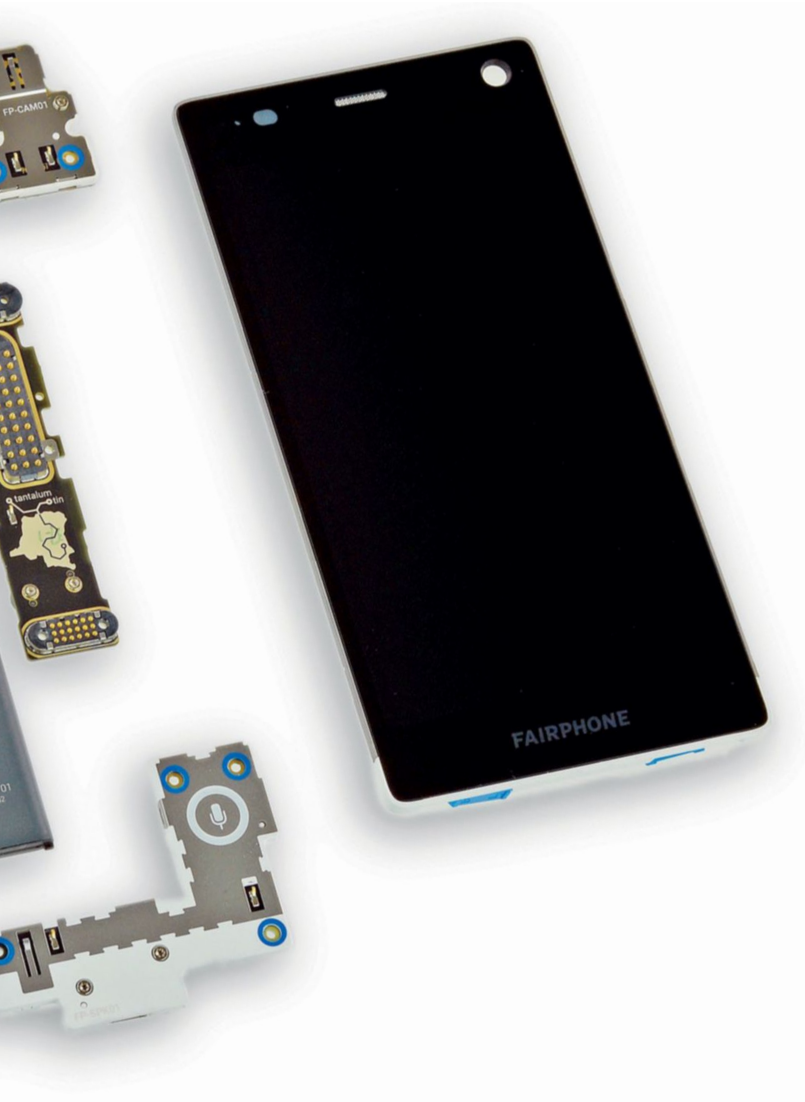
Is this the world's most repairable phone? It sure looks like it.


FP-REC01
YOURS TO OPEN, YOURS TO KEEP
To reduce the risk of fire or burns, only use this battery to power a Fairphone. Don't damage or expose it to high temperatures. See the user guide for information on safe disposal.
Rechargable Li-ion battery
Capacity: 2420mAh / Voltage: 3.8V
FP2-BAT

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Who needs tools when you have your fingers?



BACKGROUND:

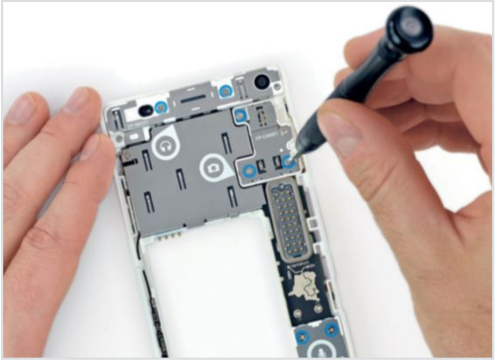
You may have heard a lot about the new Fairphone 2—the small Dutch company has been making waves with its affordable, modular, conflict-free cell phone, and we're one of the first to get our hands on its latest device. When we tore down the original Fairphone, we were pleased by its easy access and modularity. Now we're excited to see what this second-generation, responsibly-designed device has in store.

MAJOR TECH SPECS:

- 5-inch 1080p LCD display (446ppi) with Gorilla Glass 3
- Qualcomm Snapdragon 801
- 2GB LPDDR3 RAM
- 32GB internal storage with expandable storage via microSD slot
- 2,420mAh user-removable lithium-ion battery
- 8MP rear camera
- Android 5.1 Lollipop

KEY FINDINGS:

- The first item on our agenda is the translucent rear case. It's snug and secure, but snaps off with no tools required. Where's all the adhesive? Is this a dream?
- "Remove battery before releasing screen." Is this a disassembly tip on the battery? Nothing makes us happier than when manufacturers include repair instructions.
- Just like in the good old days, we lift out the battery and... that's it. No glue, no plugs, no drama.
- The lack of visible screws had us worried, but not for long, thanks to the handily-labeled clips. Removing the display assembly is just a matter of flipping the switches and sliding the panel out. For those keeping score thus far, removing the front panel keeps us at a grand total of zero tools required.
- The Fairphone is designed to be separated into modular components, but what if you want to fix an individual module? The modules are held together with Torx T5 screws—presumably to deter casual users from delving too deep—but are still easy to open up. We start with the top module: the front-facing camera pops off thanks to a simple flex cable connector. Spring contacts power the earpiece speaker, making for easy replacement of that, too. The headphone jack, the last component, is soldered to the board. Nothing major remains, so a replacement board should be cheap.
- Repairability Score: 10 out of 10 (10 is easiest). The LCD and cover glass are fused, simplifying removal, but increasing the cost of replacement. The most commonly failing components, battery and display, can be replaced without tools. Internal modules are secured with Phillips #0 screws and simple spring connectors. Individual modules can be opened, and many components individually replaced. Spring contacts allow for upgrades and easy component swaps.



The icons here make repairing this phone an absolute dream.

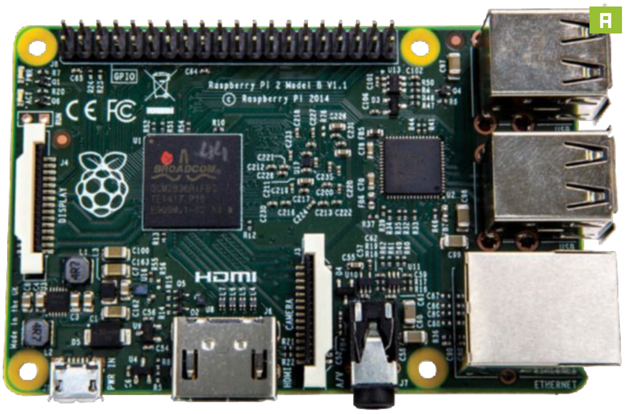
Raspberry Pi as a Wireless Print Server

YOU'LL NEED THIS

RASPBERRY Pi 2
The brilliant mini-computer costs under $45. See www.raspberrypi.org.

A PRINTER ISN'T THE MOST CONVENIENT OF PERIPHERALS. They look out of place on most desks and create a racket when spitting out pages. You could throw a few hundred dollars on a snazzy new network printer that sits in a corner somewhere, and can receive print orders from any computer on the local network. Or you could just hook up your regular USB printer to the Raspberry Pi and enjoy the same conveniences offered by top-of-the-line network printers.

If you haven't already used your printer on Linux, head to www.openprinting.org/printers to check whether your printer is compatible with the CUPS printing server software. If your printer is listed, hook it up to the Raspberry Pi using one of the USB ports. For this project, we're using the Raspbian distro, and the Pi is connected to the local network via a compatible wireless adapter. However, you can also hook the Pi up to your network via the wired Ethernet port. **–MAYANK SHARMA**



1 ACCESS YOUR RASPBERRY PI

You can follow the instructions in this tutorial by accessing the Raspberry Pi [**Image A**] remotely from any other computer on the network. Just make sure that the SSH server inside Raspbian is enabled by using the raspi-config tool. It's also a good idea to assign a fixed IP address to the Pi. You can do this easily from within your router's admin page. For this tutorial, we'll assume that the IP address of your PI is 192.168.3.111. You can now access the Pi from within Windows using the PuTTY client, or from any Linux distro with the SSH CLI command, such as:

```
$ sudo ssh pi@192.168.3.111
```

2 INSTALL CUPS

Once you're inside Raspbian, update the repositories with:

```
$ sudo apt-get update
```

and then install any updates with:

```
$ sudo apt-get upgrade
```

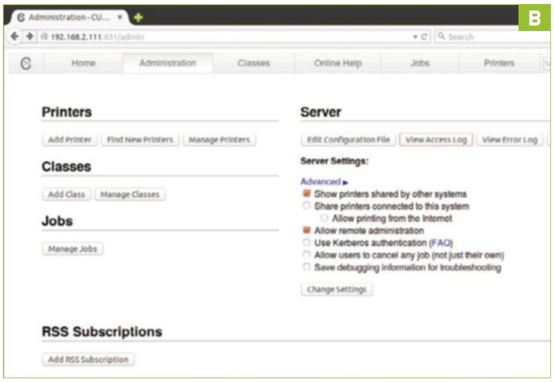
Now pull in the CUPS print server with:

```
$ sudo apt-get install cups
```

›› When it's installed, add your user to the group created by CUPS called "lpadmin" that has access to the printer queue. Unless you have created a custom user, the default user on Raspbian is named "pi." Use the following command to allow it to interact with the printer:

```
$ sudo usermod -a -G lpadmin pi
```

›› Here we use the usermod tool to add ("-a") the pi user to the lpadmin group ("-G"). By default, CUPS can only be configured from the local computer that it's installed on. Because that doesn't work in our case, we need to edit its configuration file to allow us to make changes to the server from a remote computer.



Server Settings:

☑ Show printers shared by other systems
☐ Share printers connected to this system
  ☐ Allow printing from the Internet
☑ Allow remote administration
☐ Use Kerberos authentication (FAQ)
☐ Allow users to cancel any job (not just their own)
☐ Save debugging information for troubleshooting

3 ALLOW REMOTE CONNECTIONS

First of all, you need to create a backup of the original configuration file with:

```
$ sudo cp /etc/cups/cupsd.conf /etc/cups/cupsd.conf.orig
```

›› Then open the file with the nano text editor:

```
$ sudo nano /etc/cups/cupsd.conf
```

›› Inside the file, scroll down to the following section:

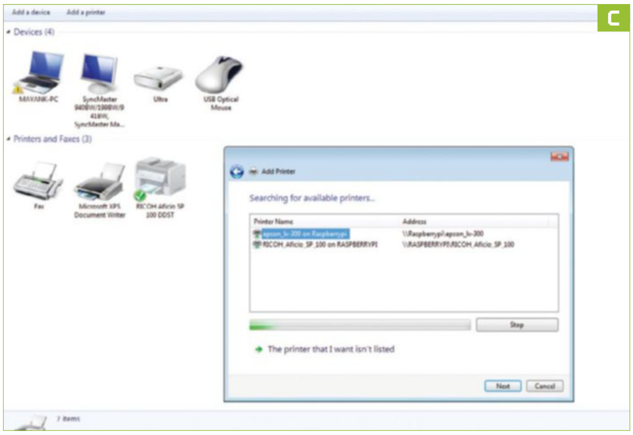
```
# Only listen for connections from the local machine
Listen localhost:631
```

›› Comment out that line and add another to ask CUPS to accept connections from any computer on the network. Make sure the section looks like this:

```
# Only listen for connections from the local machine
# Listen localhost:631
Port 631
```

›› Then scroll a bit further down in the config file until you reach the "<Location>" sections, and add a new line that reads "Allow @local" just before the close of the section. The section with the appended line should now read like this:

```
< Location / >
# Restrict access to the server
Order allow,deny
```



Searching for available printers...

Printer Name	Address
epson_lx-300 on Raspberrypi	\\Raspberrypi\epson_lx-300
RICOH_Aficio_SP_100 on RASPBERRYPI	\\RASPBERRYPI\RICOH_Aficio_SP_100

The printer that I want isn't listed

```
Allow @local
</Location>
```

›› Now add the "Allow @local" line to the other two "Location" sections: "<Location /admin>" and "<Location /admin/conf>." Save the file and restart the CUPS server with:

```
$ sudo /etc/init.d/cups restart
```

›› You should now be able to access the CUPS administration panel [**Image B**] via any computer on your local network by pointing the web browser to your Pi. Then follow the four-step walkthrough over the page to add your printer to CUPS.

4 TWEAK THE FIREWALL

Some Linux distributions ship with a restrictive iptables firewall policy that doesn't allow connections via the CUPS ports. Even if Raspbian doesn't have any such restrictions, make sure it doesn't throw up any unexpected errors by punching holes in the firewall with:

```
$ sudo iptables -A INPUT -i wlan0 -p tcp -m tcp --dport 631 -j ACCEPT
$ sudo iptables -A INPUT -i wlan0 -p udp -m udp --dport 631 -j ACCEPT
```

›› If you connect to the Pi via Ethernet instead of a wireless adapter, modify the command and replace "wlan0" with "eth0."

5 NETWORK-WIDE ACCESS

When you are through setting up your printer using the CUPS administration panel, it's time to make it accessible to the other machines on your network. While Linux distributions will have no trouble detecting your new network printer, making them visible to Windows and Apple devices requires a couple of additional steps.

›› For Windows, install the Samba server on the Pi with:

```
$ sudo apt-get install samba
```

›› Then open its configuration file ("/etc/samba/smb.conf") in the nano text editor, hunt for the section labeled "[printers]," and make sure it contains the following line:

```
guest ok = yes
```

›› Then scroll down to the "[print$]" section and change its path to the following:

```
path = /usr/share/cups/drivers
```

›› Now scroll up to the "Global Settings" section at the top of the configuration file. Modify the workgroup parameter within to point to the name of your workgroup, which by default is named "WORKGROUP." Also enable the wins support by adding the following line:

```
wins support = yes
```

›› Now save the file and restart Samba with:

```
$ sudo /etc/init.d/samba restart
```

6 CONFIGURE WINDOWS AND APPLE DEVICES

Then head over to the Windows machine, launch the "Add New Printer" wizard, and click the option to install a network printer. Thanks to the modified Samba configuration, the wizard detects and lists any printers hooked up to the Pi [**Image C**]. If you have Apple devices, you can enable support for Apple's AirPrint system, which allows you to print from the iPad and iPhone. For this, just install the Avahi daemon with "sudo apt-get install avahi-daemon" on the Pi, which will then make the connected printer visible to AirPrint-compatible devices.

7 PRINT FROM PYTHON

In addition to the ability to use our network printer from within graphical apps across all platforms, we can also use it to print from the command-line interface. Furthermore, we can also interact with the printer using the Python programming language.

›› The CUPS printing server installs a bunch of command-line tools (see box below) for interacting with the server and any connected printers. You can send files to the printer using the "lp" command, such as:

```
$ lp ~/docs/a_text_file.txt
```

›› If you have multiple printers, you can print to a particular printer by specifying its name, such as:

```
$ lp ~/docs/another-text.txt -d EPSON_LX-300
```

CUPS COMMAND-LINE UTILITIES

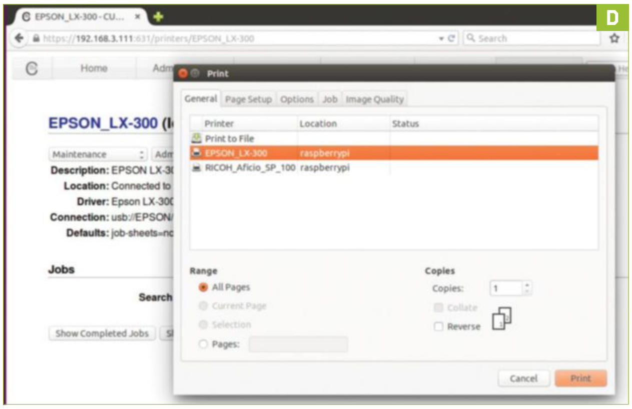
The CUPS printing system ships with a number of nifty little command-line utilities. In fact, you can set up and configure all aspects of your printer from the CLI. Let's run through some of the most useful commands that will help you manage the printer better.

We've already seen the "lp" command, which queues a file for printing on the default printer. The default printer is specified in the "PRINTER" variable. You can specify it with the command "export PRINTER=printer-name" where "printer-name" is the name of the printer you specify in Step 2 of the walkthrough over the page.

If you have multiple printers, use the "-d" option to specify the printer you wish to print to. For example, "lp -d HP-printer file.txt" prints the file on the HP printer, which isn't set as the default.

To influence the characteristics of the printed output, use the "-o" option to specify a variety of options. For example, "lp -o landscape -o fit-to-page -o media A4 file.jpg" fits the image into A4 size specifications, and prints it in landscape. Refer to the CUPS documentation (www.cups.org/documentation.php/options.html#OPTIONS) for a list of options.

If you mistakenly print a large file and want to stop the print job before you waste too much paper, you can use the "lpq" command to print a list of all the print jobs currently in the queue. The command also lists the file that each job is printing and its size, so you can easily identify the job ID assigned to each. Make note of it because you need it to cancel the print job. For instance, the command "cancel 2" cancels the job with the ID 2.



EPSON_LX-300 (I

Maintenance

Description: EPSON LX-30

Location: Connected to

Driver: Epson LX-300

Connection: usb://EPSON/

Defaults: job-sheets=no

Printer	Location	Status
Print to File		
EPSON_LX-300	raspberrypi	
RICOH_Aficio_SP_100	raspberrypi	

● All Pages
○ Current Page
○ Selection
○ Pages:

Copies: 1
☐ Collate
☐ Reverse

8 USING PYTHON

When you use the commands with a PDF or image file, CUPS converts the files using the printer drivers. You can also use Python to generate printer-friendly content. This is best done with the PyCups library, which provides Python bindings for the CUPS server. Install the library with:

```
$ sudo apt-get install python-cups.
```

» Then create an example.py Python script with:

```
import cups
conn = cups.Connection()
printers = conn.getPrinters ()
for printer in printers:
print printer, printers[printer]["device-uri"]
```

» The script fetches details about all the printers managed by CUPS and prints their name and device address to the screen. When you execute the script, it produces an output like this:

```
EPSON_LX-300 usb://EPSON/LX-300+?serial=L010209081
RICOH_Aficio_SP_100 usb://RICOH/Aficio?serial=T382M977983
```

» You can also print files from the Python script using the "printFile" function, by specifying them in the format:

```
$ printFile (name of the printer, filename to print, job
title,options)
```

9 MODIFY EXAMPLE.PY

Open the previous example.py script and add:

```
 file = "/home/pi/testfile.txt"
printer_name=printers.keys()[0]
conn.printFile (printer_name, file, "Project Report", {})
```

» The first line saves the name of the file you wish to print inside a variable named "file." The second fetches the list of printers and saves the first name, which is the default printer inside a variable named "printer_name." The third line uses the first two variables and prints the file in the specified format.

» A more interesting example is to use the wkHTMLtoPDF toolkit to convert HTML pages into PDFs and pass them on to the printer, from within a Python script.

» Before you can install the toolkit, install the required components and a set of fonts to process the web pages:

```
$ sudo apt-get install xvfb xfonts-100dpi xfonts-75dpi
xfonts-scalable xfonts-cyrillic
```

» Then install the tool with "sudo apt-get install wkhtmltopdf" before installing the Python wrapper with:

```
$ sudo pip install git+https://github.com/qoda/python-
wkhtmltopdf.git
```

» You can now use the following to convert a web page into a PDF file:

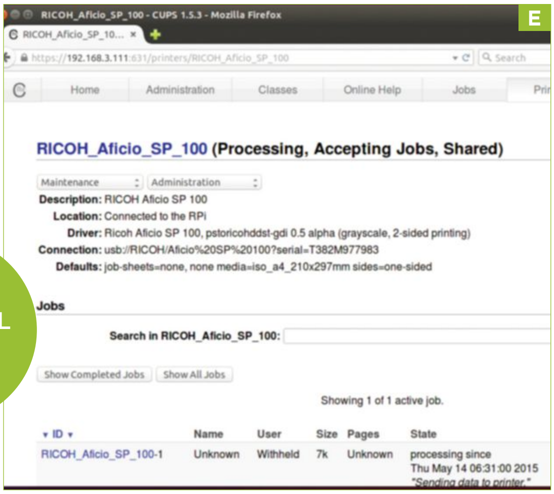
```
from wkhtmltopdf import WKHtmlToPdf

wkhtmltopdf = WKHtmlToPdf (
  url='http://www.maximumpc.com',
  output_file='/home/pi/docs/mpc.pdf',
)
wkhtmltopdf.render()
```

» The code saves the main page of the *Maximum PC* website as a PDF in the "/home/pi/docs" directory.

10 PUT IT ALL TOGETHER

Refer to the following code to see how the pieces fit together—it converts a page into a PDF and



RICOH_Aficio_SP_100 (Processing, Accepting Jobs, Shared)

Description: RICOH Aficio SP 100

Location: Connected to the RPi

Driver: Ricoh Aficio SP 100, pstoricohddst-gdi 0.5 alpha (grayscale, 2-sided printing)

Connection: usb://RICOH/Aficio%20SP%20100?serial=T382M977983

Defaults: job-sheets=none, none media=iso_a4_210x297mm sides=one-sided

Jobs

Search in RICOH_Aficio_SP_100:

Showing 1 of 1 active job.

ID	Name	User	Size	Pages	State
RICOH_Aficio_SP_100-1	Unknown	Withheld	7k	Unknown	processing since Thu May 14 06:31:00 2015 "Sending data to printer."

ANOTHER PI TUTORIAL NEXT MONTH

ADMINISTERING CUPS

In addition to adding printers, the CUPS web interface provides access to various other useful settings. You can administer most of the printing tasks from the "Administration" tab, which houses settings under various categories. Under the "Server" section, for instance, you can find options to tweak the configuration of the server, as well as view various types of access and error logs.

Using the "Manage Printers" button under "Printers," you can control the settings for individual printers. Every printer's page has options under two pull-down menus labeled "Maintenance" and "Administration" [**Image E**]. From under the "Maintenance" menu, you can print a test page, a self-test page, clean print heads, and manage print jobs.

To customize the behavior of the printer, use the "Administration" menu to tweak its default options, set it as the default printer, restrict user access, modify its settings, or delete it from the CUPS server altogether. Beside the "Administration" tab, there's a couple of other important tabs we should mention as well.

For starters, you need to switch to the "Classes" tab for printer class management. A class is a collection of several printers. When you send a print job to a class, CUPS automatically assigns the job to the next available printer, instead of waiting for a specific printer to be ready.

Then there's the "Jobs" tab, which enables you to view and manage all print jobs that are currently in the print queue.

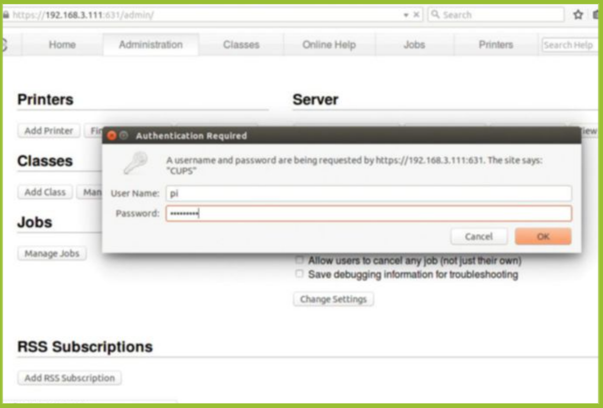
prints it out.

```
#!/usr/bin/env python
import cups
from wkhtmltopdf import WKHtmlToPdf
wkhtmltopdf = WKHtmlToPdf(
  url='http://www.maximumpc.com',
  output_file='/home/pi/maxpc.pdf',
)
wkhtmltopdf.render()
conn = cups.Connection()
printers = conn.getPrinters()
for printer in printers:
    print printer, printers[printer]["device-uri"]
file="/home/pi/tuxradar.pdf"
printer_name=printers.keys()[0]
conn.printFile (printer_name, file, "PDF Print", {})
```

›› The script first converts the homepage of www.maximumpc.com into a PDF. It then connects to CUPS, prints a list of attached and configured printers on the screen, and uses the default printer to print the PDF. The PyCups library is full of methods (https://pythonhosted.org/pycups/) to control all aspects of CUPS.

›› Note: All distros can access the USB printers connected to the Pi without tweaks [**Image D**]. Happy printing! ⏻

ADD A PRINTER


https://192.168.3.111:631/admin/
Search
Home
Administration
Classes
Online Help
Jobs
Printers
Search Help
Printers
Add Printer
Server
Classes
Add Class
Jobs
Manage Jobs
Authentication Required
Cancel
OK
Change Settings
RSS Subscriptions
Add RSS Subscription

A username and password are being requested by https://192.168.3.111:631. The site says: "CUPS"

User Name: pi

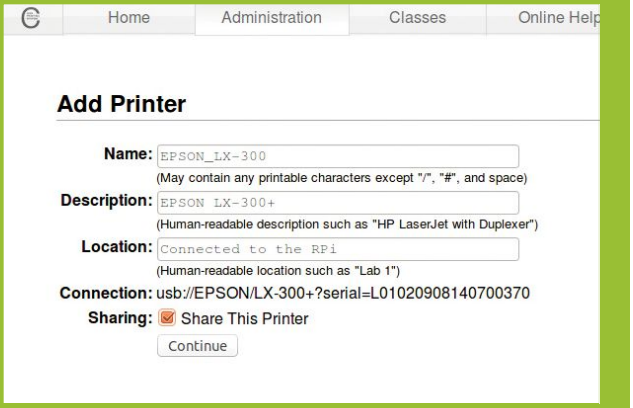
Password: ••••••••••

☐ Allow users to cancel any job (not just their own)

☐ Save debugging information for troubleshooting

1. THE CUPS DASHBOARD

The CUPS print server includes a built-in web server that powers its configuration panel. It's running on port 631 on the Raspberry Pi, which in our case is 192.168.3.111:631. Access the address from any browser on the network. You have to accept its security certificate, and then log in to the interface using the credentials of the user you've added to the "lpadmin" group, which in our case is the "pi" user.


Home
Administration
Classes
Online Help
Continue

Add Printer

Name: EPSON_LX-300

(May contain any printable characters except "/", "#", and space)

Description: EPSON LX-300+

(Human-readable description such as "HP LaserJet with Duplexer")

Location: Connected to the RPi

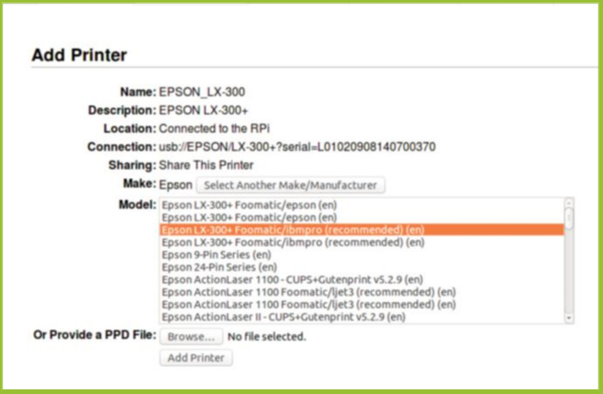
(Human-readable location such as "Lab 1")

Connection: usb://EPSON/LX-300+?serial=L010209081407003700

Sharing: ☑ Share This Printer

2. ADD A PRINTER

Once logged in, switch to the "Administration" tab, and click the "Add Printer" button, which brings up a list of printers. Toggle the radio button next to your printer, and head to the next step. Here you're asked to add or edit the name, description, and location of the printer. Make sure you enable the "Share This Printer" option to make the printer accessible all over the network.


Select Another Make/Manufacturer
Browse...
Add Printer

Add Printer

Name: EPSON_LX-300

Description: EPSON LX-300+

Location: Connected to the RPi

Connection: usb://EPSON/LX-300+?serial=L01020908140700370

Sharing: Share This Printer

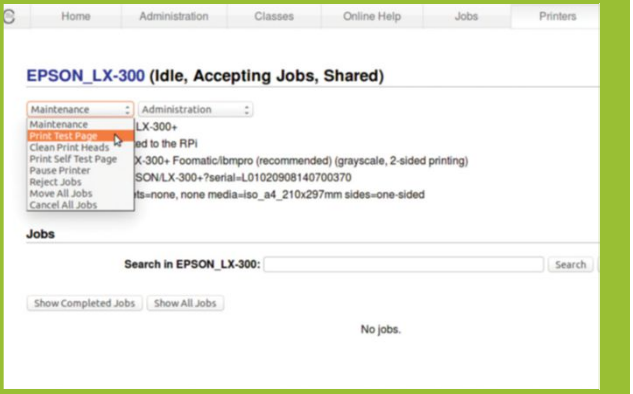
Make: Epson

Model:
Epson LX-300+ Foomatic/epson (en)
Epson LX-300+ Foomatic/epson (en)
Epson LX-300+ Foomatic/ibmpro (recommended) (en)
Epson LX-300+ Foomatic/ibmpro (recommended) (en)
Epson 9-Pin Series (en)
Epson 24-Pin Series (en)
Epson ActionLaser 1100 - CUPS+Gutenprint v5.2.9 (en)
Epson ActionLaser 1100 Foomatic/ljet3 (recommended) (en)
Epson ActionLaser 1100 Foomatic/ljet3 (recommended) (en)
Epson ActionLaser II - CUPS+Gutenprint v5.2.9 (en)

Or Provide a PPD File: No file selected.

3. SELECT A DRIVER

You're asked to choose a driver for the selected printer. CUPS shows you a list of drivers based on the make of printer. Chances are that several of the drivers are marked "Recommended." However, scroll through the list until you find the driver for your exact model. Alternatively, if you have a PPD file for the printer's driver, click the "Browse" button and navigate to it.


Home
Administration
Classes
Online Help
Jobs
Printers
Maintenance
Administration
Maintenance
Print Test Page
Clean Print Heads
Print Self Test Page
Pause Printer
Reject Jobs
Move All Jobs
Cancel All Jobs
Search
Show Completed Jobs
Show All Jobs

EPSON_LX-300 (Idle, Accepting Jobs, Shared)

LX-300+
ed to the RPi
X-300+ Foomatic/ibmpro (recommended) (grayscale, 2-sided printing)
SON/LX-300+?serial=L01020908140700370
ts=none, none media=iso_a4_210x297mm sides=one-sided

Jobs

Search in EPSON_LX-300:

No jobs.

4. SET DEFAULT OPTIONS

In the final step, CUPS enables you to set some generic print settings, such as page size and source. The options vary from one printer to another, and might spread over several sections. When you've finished, click "Set Default Options." You're then taken to the main administration page for that printer. Use the "Maintenance" pull-down menu to print a test page.

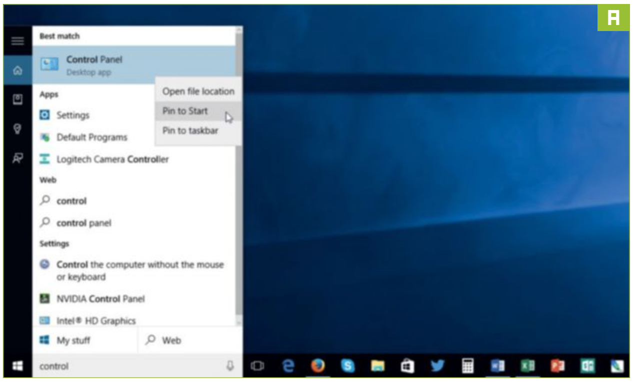
Rediscover the Control Panel

YOU'LL NEED THIS

WINDOWS 10
The old Control Panel is still in there somewhere...

DESPITE FIRST APPEARANCES, Windows 10 hasn't killed off the Control Panel. Although you're strongly pushed toward the new—and admittedly improved—Settings dialog, which was first seen in Windows 8, the old Control Panel still lurks behind the scenes, giving you access to just about every system setting imaginable. And while a fair bit of its functionality has now been incorporated into Settings, there are still plenty of times when you'll need to access the Control Panel to tweak certain parts of your PC.

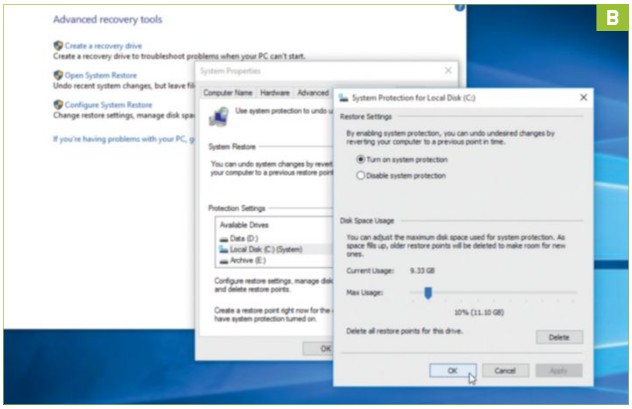
In some cases, direct links to certain Control Panel applets can be found in Settings itself—look for references to "advanced settings" to access them. However, in this tutorial, we'll focus on revealing key settings that are hidden behind the scenes—read on to find out more about them, plus gain that all-important access. –**NICK PEERS**


A
Best match
Control Panel
Desktop app
Open file location
Pin to Start
Pin to taskbar
Apps
Settings
Default Programs
Logitech Camera Controller
Web
control
control panel
Settings
Control the computer without the mouse or keyboard
NVIDIA Control Panel
Intel® HD Graphics
My stuff
Web
control

1 OPEN CONTROL PANEL AND GET SYSTEM INFO

The quickest way to open the Control Panel is to right-click the "Start" button and select "Control Panel" from the Quick Access menu, or make it even more accessible by typing "control" into the Search box, then right-clicking "Control Panel," and choosing "Pin to Start" or "Pin to Taskbar" [**Image A**].

» The System Control Panel reveals key information about your version of Windows and its system type (32-bit or 64-bit). It can be accessed by right-clicking the "Start" button once again and choosing "System," or by clicking "Start," right-clicking "File Explorer," and choosing "Properties." You can also review your current network name and workgroup—click "Change settings" to edit these.


B
Advanced recovery tools
Create a recovery drive
Open System Restore
Configure System Restore
System Properties
Computer Name
Hardware
Advanced
System Restore
Protection Settings
Available Drives
Data (D:)
Local Disk (C:) (System)
Archive (E:)
OK
System Protection for Local Disk (C:)
Restore Settings
Disk Space Usage
Delete
OK
Cancel
Apply

Create a recovery drive to troubleshoot problems when your PC can't start.

Undo recent system changes, but leave fil

Change restore settings, manage disk spa

If you're having problems with your PC, g

Use system protection to undo u

You can undo system changes by revert your computer to a previous restore point

Configure restore settings, manage disk and delete restore points.

Create a restore point right now for the have system protection turned on.

By enabling system protection, you can undo undesired changes by reverting your computer to a previous point in time.

● Turn on system protection
○ Disable system protection

You can adjust the maximum disk space used for system protection. As space fills up, older restore points will be deleted to make room for new ones.

Current Usage: 9.33 GB

Max Usage: 10% (11.10 GB)

Delete all restore points for this drive.

2 ACCESS SYSTEM RESTORE

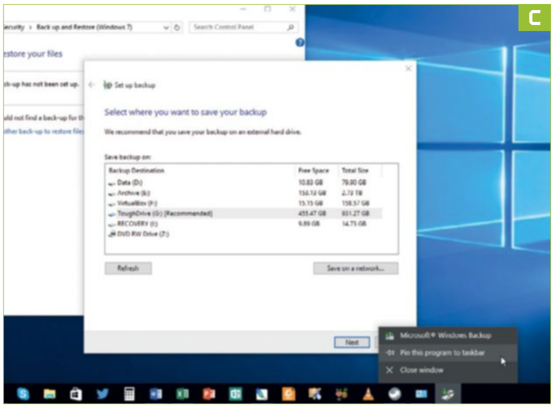
System Restore may be switched off by default in Windows 10—access its settings by clicking "System Protection" on the System Control Panel, or by typing "recovery" in the Search box, and clicking "Recovery," then "Configure System Restore." Select your system drive, then click "Configure." Switch it on and allocate 5-10 percent of drive space before clicking "OK" [**Image B**].

» The Recovery applet also enables you to create a recovery drive to help troubleshoot problems when Windows won't boot—leaving "Back up system files to the recovery drive" checked means you'll need a larger USB drive, but will be able to reinstall Windows from the drive. However, it won't always work. Leave it unchecked to create a basic drive with troubleshooting tools only.

3 RESTORE PC AND ACCESS ADVANCED SETTINGS

System Restore can be opened via the Recovery applet, too, and you can use it to roll your misbehaving PC back to an earlier point in time. Pick a point, click "Scan for affected programs" to see what will be affected, then restore your PC. If it fails, try an earlier Restore Point—click "Show more Restore Points" to reveal all supported points—or just undo the change to try a different tack.

» You can access additional system tweaks via the "Advanced system settings" button under "System," or by typing "advanced" into the Search box. Click "Settings..."


C
ecurity › Back up and Restore (Windows 7)
Search Control Panel
estore your files
Set up backup
Refresh
Save on a network...
Next
Microsoft® Windows Backup
Pin this program to taskbar
Close window

ck-up has not been set up.

uld not find a back-up for th

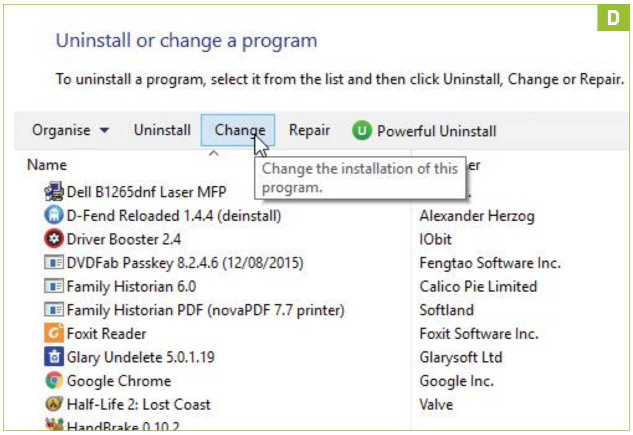
ther back-up to restore files

Select where you want to save your backup

We recommend that you save your backup on an external hard drive.

Save backup on:

Backup Destination	Free Space	Total Size
Data (D:)	10.83 GB	79.00 GB
Archive (E:)	153.13 GB	2.73 TB
VirtualBox (F:)	15.15 GB	158.57 GB
ToughDrive (G:) [Recommended]	455.47 GB	931.27 GB
RECOVERY (I:)	9.89 GB	14.73 GB
DVD RW Drive (Z:)		


D
Organise ▾
Uninstall
Change
Repair
Powerful Uninstall
Name
er

Uninstall or change a program

To uninstall a program, select it from the list and then click Uninstall, Change or Repair.

Change the installation of this program.

Name	
Dell B1265dnf Laser MFP	
D-Fend Reloaded 1.4.4 (deinstall)	Alexander Herzog
Driver Booster 2.4	IObit
DVDFab Passkey 8.2.4.6 (12/08/2015)	Fengtao Software Inc.
Family Historian 6.0	Calico Pie Limited
Family Historian PDF (novaPDF 7.7 printer)	Softland
Foxit Reader	Foxit Software Inc.
Glary Undelete 5.0.1.19	Glarysoft Ltd
Google Chrome	Google Inc.
Half-Life 2: Lost Coast	Valve
HandBrake 0.10.2	

under "Performance" if your PC is struggling with graphics effects, and you can also tweak virtual memory settings. Click "Settings..." under "Start-up and Recovery" to stop Windows automatically restarting after a blue screen of death.

4 FIND THE OLD ACTION CENTER AND BACKUP FEATURE

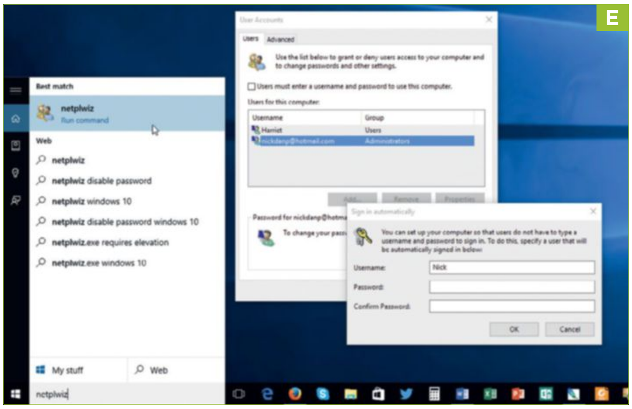
The Notification Center appears—on the surface—to have superseded the old Action Center, but in actual fact it's simply been renamed "Security and Maintenance," and the quickest way to get to it is via the Quick Access menu (right-click the "Start" button). You'll find it's still the go-to place for security and maintenance messages, as well as accessing troubleshooters.

›› While Windows 10 supports Windows 7's Backup feature, it favors File History via the Search box and Settings [**Image C**]. If you prefer the older backup tool, type "Windows 7" into the Search box to access it. Once you've clicked "Set up backup" to start it, right-click the Taskbar shortcut, and choose "Pin this program to Taskbar" to give you easy one-click access to the tool in future.

5 COMBINE DRIVES AND MANAGE DEFAULT APPS

Storage Spaces lets you combine two or more smaller drives into one large virtual drive (or provide protection against data loss without having to set up a RAID array). Type "storage" into the Search box, and click "Storage Spaces." Click "Create a new pool and storage space," select the drives you want to join (read the warning about deleting data), and let Windows do the rest.

›› Type "default" into the Search box and click the "Default Programs" shortcut to manage your apps and autoplay settings. Click "Set Default Programs" to select an app, review what defaults it has and—if necessary—assign it all available defaults to ensure it works correctly. Choose "Change AutoPlay Settings" to decide what happens when you insert CDs or other media.


E
Best match
netplwiz
Run command
Web
netplwiz
netplwiz disable password
netplwiz windows 10
netplwiz disable password windows 10
netplwiz.exe requires elevation
netplwiz.exe windows 10
My stuff
Web
netplwiz
User Accounts
Users
Advanced
Add...
Remove
Properties
Sign in automatically
OK
Cancel

Use the list below to grant or deny users access to your computer and to change passwords and other settings.

☐ Users must enter a username and password to use this computer.

Users for this computer:

Username	Group
Harriet	Users
nickdanp@hotmail.com	Administrators

Password for nickdanp@hotma

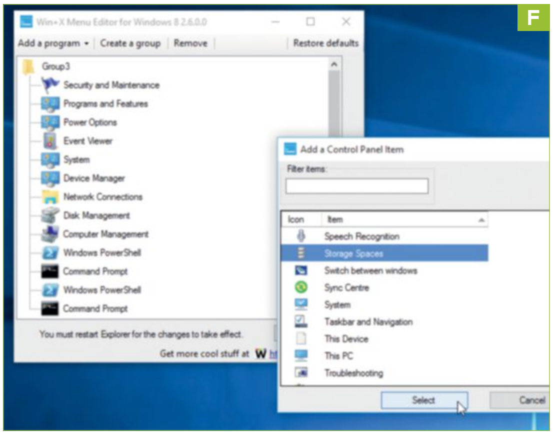
To change your pass

You can set up your computer so that users do not have to type a username and password to sign in. To do this, specify a user that will be automatically signed in below:

Username: Nick

Password:

Confirm Password:


F
Win+X Menu Editor for Windows 8 2.6.0.0
Add a program ▾
Create a group
Remove
Restore defaults
Group3
Security and Maintenance
Programs and Features
Power Options
Event Viewer
System
Device Manager
Network Connections
Disk Management
Computer Management
Windows PowerShell
Command Prompt
Windows PowerShell
Command Prompt
Get more cool stuff at
Add a Control Panel Item
Filter items:
Icon
Item
Speech Recognition
Storage Spaces
Switch between windows
Sync Centre
System
Taskbar and Navigation
This Device
This PC
Troubleshooting
Select
Cancel

You must restart Explorer for the changes to take effect.

6 PROGRAMS AND FEATURES

Need to repair or make changes to a program rather than uninstall it? The Settings app doesn't cut it. Instead, right-click the "Start" button and choose "Programs and Features" to access the more powerful Control Panel [**Image D**]—you can also manage (or remove) Windows Updates from here, plus switch on (or off) Windows features, such as the XPS viewer and services.

›› Wonder where Windows stores all those passwords it saves automatically? Type "cred" into the Search box, and click "Credential Manager." Expand "Web Credentials" to see which passwords have been saved by Edge, Internet Explorer, and other apps (as well as Windows)—expand one to view or remove it, using your user account password as collateral when requested.

7 EDIT AUDIO SETTINGS AND BYPASS LOGIN SCREEN

There's no dedicated Sound section in Settings, but the old Control Panel is easily accessible from the Taskbar Notification area—right-click the volume icon, and choose "Playback" to manage default playback (and recording) devices. Select an entry to make it the default, configure speaker settings, and tweak advanced properties, such as adjusting sound level and quality.

›› Type "netplwiz" into the Search box, and click the entry that appears to access a hidden User Accounts Control Panel [**Image E**]. If you're the only user of your PC, you can configure Windows to bypass the lock and login screen by selecting your username, then unchecking "Users must enter a username and password to use this computer." Click "Apply," enter password (carefully!), and click "OK."

8 SET UP SPEECH AND ADD PERMANENT SHORTCUTS

Type "speech" into the Search box and click "Speech Recognition" under "Settings"—you will need to provide a headset or microphone—then click "Start Speech Recognition," which will take you step by step through setting up your computer and training Windows to recognize your spoken commands. Other options include a training program that will help Windows to learn how you speak.

›› Finally, add your favorite Control Panel items to the Quick Access menu for easy access [**Image F**]. Download Win+X Menu Editor (http://winaero.com/download.php?view.21), extract the program files, and run the x64 (64-bit) or x86 (32-bit) version, depending on your Windows system. Choose "Add a program → Add a Control Panel item" to add any Control Panel applet to the menu. ⏻

Discover Advanced Lightroom Tips

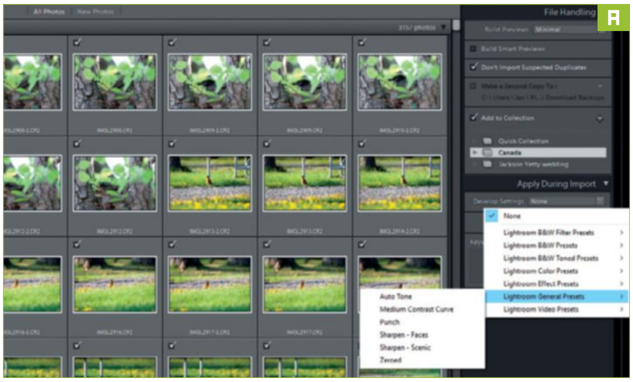
YOU'LL NEED THIS

ADOBE LIGHTROOM CC
Subscribe to various Adobe packages at www.abobe.com.

PHOTOS
To import and edit.

ADOBE'S RAW IMAGE WORKFLOW APP is a powerful beast, but its modular nature can confuse people, especially those who expect it to work just like Photoshop. Once you've got the hang of it, however, it's an app you'll find yourself spending a great deal of time using, especially if you take a lot of pictures. In this situation, you can find yourself applying the same edits time and again to subsequent frames, but there are many techniques to speed up or even automate this process.

Lightroom's strength lies in its non-destructive editing—your changes exist only as entries in a database until you export the final file, so they can be quickly reversed, treating the original raw file much like a photographic negative. In this way, it's possible to produce markedly different end results from the same exposure, opening up a new side to photography. If you aren't shooting raw images on your DSLR, you can get a free 30-day trial of Lightroom, so give it a try. **–IAN EVENDEN**


A
File Handling
Don't Import Suspected Duplicates
Add to Collection
Quick Collection
Canada
Apply During Import
Develop Settings: None
None
Lightroom B&W Filter Presets
Lightroom B&W Presets
Lightroom B&W Toned Presets
Lightroom Color Presets
Lightroom Effect Presets
Lightroom General Presets
Lightroom Video Presets
Auto Tone
Medium Contrast Curve
Punch
Sharpen - Faces
Sharpen - Scenic
Zeroed

1 EDIT IN CAMERA

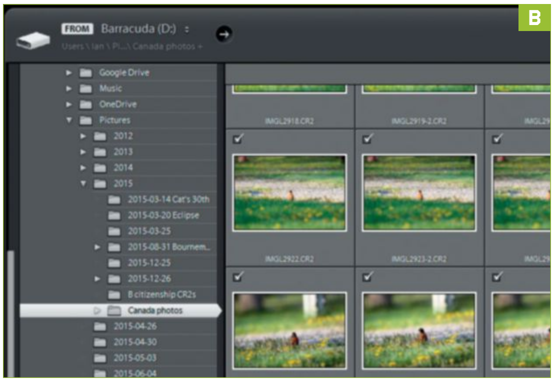
Not strictly a Lightroom tip, but make use of that little screen on the back of your camera, and delete the shots you know you don't want before they even reach your PC. Raw files can be large, and most cameras and card readers still use slow USB 2.0, unless you bought yours very recently. The camera LCD gets a bad rap for its lack of sharpness and color accuracy, but it's perfect for identifying those shots that just aren't worth bothering with.

2 IMPORT PRESETS

If you find yourself applying the same alterations to every single shot, why not get them applied automatically as they're imported into your Lightroom library? Create a new preset with the adjustments you commonly make [**Image A**], give it a recognizable name, and save it. Next time you import images, drop down the "Apply During Import" menu, and select your preset from "Develop Settings." Every image that's imported will have the same preset applied.

3 MANAGE YOUR LIBRARY

By default, Lightroom wants to store your images in its Catalog file. This is fine as long as your PC has plenty of storage, your image files aren't spread over a horde of USB archive drives, and you never want to use anything other than Lightroom to develop your raws. As an alternative, you can tell the app to suck the files off your memory cards as usual, but store them in a sensible hierarchy on a hard drive, and only add a cross-reference to the Catalog. Do this by selecting "Add" at the top of the "Import" screen, and choosing a new home for your files on the right—allowing the app to sort images into dated folders is a good way of organizing them. Then hit "Import" as normal.

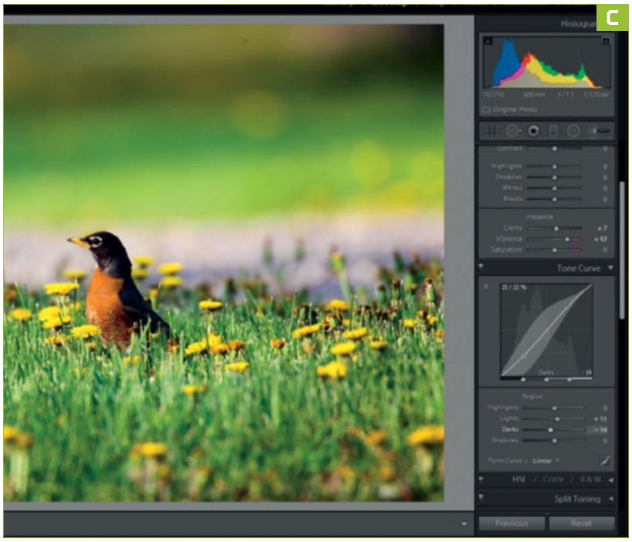

B
FROM
Barracuda (D:)
Users \ Ian \ Pi...\ Canada photos
Google Drive
Music
OneDrive
Pictures
2012
2013
2014
2015
2015-03-14 Cat's 30th
2015-03-20 Eclipse
2015-03-25
2015-08-31 Bournem...
2015-12-25
2015-12-26
B citizenship CR2s
Canada photos
2015-04-26
2015-04-30
2015-05-03
2015-06-04
IMGL2918.CR2
IMGL2919-2.CR2
IMGL2922.CR2
IMGL2923-2.CR2

4 SMART PREVIEWS

The downside to not using the Lightroom Catalog on your PC's internal storage is that if you're a laptop user and want to work on your photos while traveling, you need to drag your external drive with you. Smart Previews get around this, at the cost of slightly inflating your Catalog's size. They're a higher-res preview than normal, and you can make adjustments to them as though they were the original file—you just can't export the end result until you reconnect your external storage, when the changes are applied to the original raw file. Create Smart Previews by checking the box in the "Import" window [**Image B**], or for an individual image, by clicking "Original Photo" under the histogram in the "Develop" module. It doesn't make much sense but it works.

5 DNG FILES

Raw file formats are proprietary—if Canon makes a change to CR2, or releases a new camera, it takes the software makers a short time to catch up. In the future, it's possible support for old cameras could be dropped from new software. It's unlikely, because the outcry from photographers with large collections would be deafening, but you can protect against it by converting your raws into Adobe's much more open file format, DNG, at import, by selecting "Copy as DNG."



6

USE “CURVES”

Found just under “Basic” in the “Develop” module, the “Curves” palette [Image C] works just the way it does in Photoshop (note that the version in Photoshop Elements is cut-back and crippled, so if you’ve rejected it based on that, give the Lightroom version a try). “Curves” enables you to alter specific groups of tones in your image without affecting others, and builds on top of any edits you’ve already made in “Basic.”

7

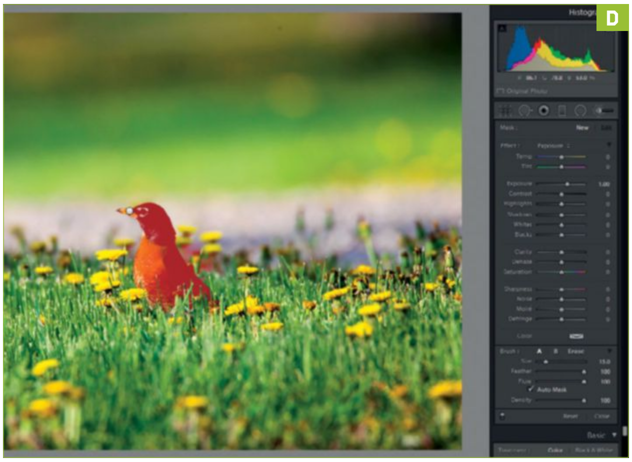
ADJUSTMENT BRUSHES CAN BE STACKED

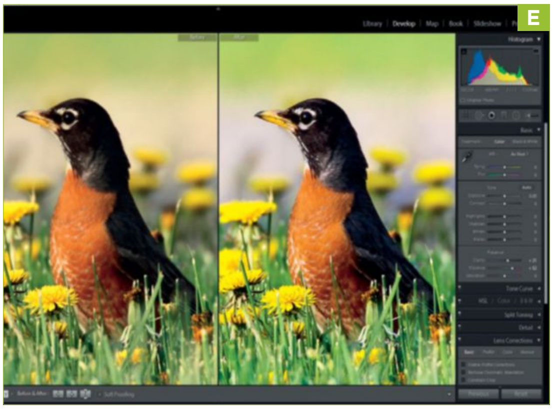
At first glance, it looks as though an adjustment brush—an edit that’s painted on specific parts of an image—is a one-shot effect, but the “New” button at the top of the palette means you can have several [Image D]. While it’s not as flexible or intuitive a system as Photoshop’s layers, you can apply a great many adjustments this way.

8

THE “SATURATION” SLIDER IS NOT YOUR FRIEND

“Saturation” increases the strength of colors globally, no matter what they are [Image E]. This can make a dramatic sky or landscape look great, but conversely it can do terrible things to a portrait. Try using “Vibrance” instead, because it boosts the colors that are least saturated more than it does those that already have plenty of punch. It also seems to recognize and protect skin tones against the invasion of nuclear magenta, which you can get from “Saturation.”





9

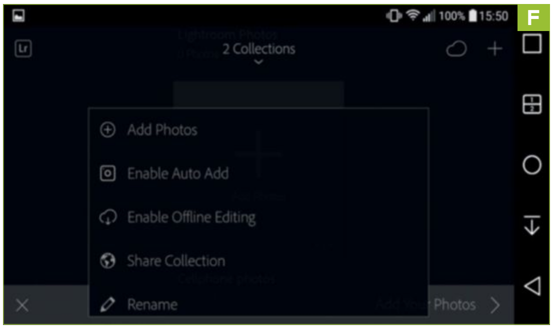
WATCH OUT FOR “CLARITY” AS WELL

This slider can bring out skin imperfections in a portrait or produce haloes around high-contrast areas. While it certainly has its uses—it affects mid-tone contrast in the image—it’s one to apply with an adjustment brush or mask.

10

BRING CELL PHONE PIX INTO LIGHTROOM

Although it’s marketed as a raw image editing application, Lightroom will very happily edit JPEGs in the same way. To easily get photos from your cell phone to a Lightroom Collection, install the Lightroom Mobile app (iOS/Android), sign in, and turn on “Auto-Add Photos” in the settings (tap the “LR” icon) [Image F]. Create a new Collection, give it an obvious name, tap “...” to bring out its settings, and select “Enable Auto-Add.” Your cell phone photos should now be synched with your desktop app as long as you sign in to both with the same account. ⏻



KEYBOARD SHORTCUTS

A professional photographer once told us that the best Lightroom tip was to maximize the screen area your photos take up (Shift-Tab), and use keyboard shortcuts to move around the app. And it’s true, it is a faster way to work. So hitting “G” takes you to the library grid view, “D” opens the selected photo in Develop, “R” takes you to Develop with a crop box already in place, “F” makes the selected photo full-screen, and “L” dims the interface if it’s getting distracting.

There’s more: F5 through F8 show and hide the various panels, and Ctrl-Alt-Numbers 1-7 take you to the modules. Ctrl-Alt-Up Arrow takes you back to the previous module, and Shift-F11 puts your secondary monitor into full-screen mode.

BUILD IT

ALEX CAMPBELL **ASSOCIATE EDITOR**

The VR Gaming Rig Revisited

This rig will have you playing games on screens or in a VR headset

LENGTH OF TIME: **1–3 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

LOOKING FORWARD TO GAMING...

LAST YEAR, we built a PC based on the recommended minimum specs for the Oculus Rift. Now that the Rift is ready for the public, we wanted to revisit the idea of what you'd need for a great virtual reality experience. It turns out, we ended up building a rock-solid gaming rig that would be great for playing any game, not just running Oculus VR.

We also wanted to keep this build on the small side. For many people, there's a big argument for going full-ATX. Air flow is one big consideration, because Mini-ITX form factors can often be starved of cool air. Expandability is the other concern, but not everyone has either the want or need to upgrade with a second video card.

We think VR is going to be one of the most important new technologies of 2016. Sure, you could build a rig at the minimum specification, but where's the fun in that? Didn't your teachers tell you that just doing the minimum doesn't get you anywhere in life? This rig goes above and beyond what is required, and offers a solid VR rig as well as the ability to play some games at 4K resolutions.

GOING BEYOND THE MINIMUM

WHEN WE STARTED THINKING ABOUT this build, we were aiming for an ideal VR experience. We also wanted a solid gaming PC that would show off the Intel Core i7-6700K Skylake processor, the successor to the still-awesome i7-4790K Devil's Canyon. We don't have anything against the Haswell/Devil's Canyon platform that Oculus VR had been spec'd to, but we wanted to use the latest technology we had.

The original Oculus minimum spec called for a Core i5-4590. Last year, we went with the Core i7-4790K. That build also featured Asus's GeForce GTX 970 DCMOC, a shorty card made with Mini-ITX builds in mind. We decided to jump up to a full-size GTX 980 Ti, which is still only bested by the $1,000 GTX Titan X.

We mounted the Core i7-6700K and the 980 Ti on to Asus's Maximus VIII Impact Mini-ITX motherboard, which, while full of great features, does lack an M.2 connector or any USB 2.0 headers.

To fit the full-size 980 Ti into a Mini-ITX build, we needed a special case. We turned to the Phanteks Enthoo Evolv, which offers lots of room but still feels compact. For memory, we went with a pair of 8GB Corsair Dominator Platinum DDR4 DIMMs, clocked at 2,666MHz. Not the cheapest kit but the DIMMS are reliable and look handsome. To store our OS and games, we went with a 250GB Samsung 850 Evo and a 1TB WD Black. We had to go with the 2.5-inch SATA Evo (no M.2 port on the mobo), though we'd have preferred M.2.

INGREDIENTS

PART		STREET PRICE
Case	Phanteks Enthoo Evolv ITX	$70
Motherboard	Asus Maximus VIII Impact	$239
CPU	Intel Core i7-6700K	$360
Memory	16GB (2x 8GB) Corsair Dominator Platinum DDR4 2666	$125
GPU	Zotac GeForce GTX 980 Ti (reference)	$630
PSU	EVGA SuperNOVA NEX 650W 80 Plus Gold	$90
SSD	Samsung 850 Evo 250GB	$84
HDD	WD Black 1TB	$75
Cooler	Intel OEM cooler	$15
Total		$1,688

1

BOLSTERING SKYLAKE

WHEN THE NEW CROP OF SKYLAKE CPUS started hitting the market, a few organizations noticed that Skylake CPUs would bend under pressure. The issue comes from the use of aftermarket CPU coolers. When too much pressure is applied to the top of the CPU, its corners can give way, rendering the CPU unusable. Intel claims that Skylake CPUs have the exact same pressure specs as Haswell chips, despite Skylake's noticeably thinner substrate, while cooler-makers claim their products conform to the standard, without directly blaming Intel. The result is a stalemate. Luckily, some mobo makers are shipping reinforcing brackets for their Skylake boards. The Maximus VIII Impact ships with a plastic bracket that helps spread the pressure of a cooler evenly.

THIS SIDE UP
INTEL CORE i7
i7-6700K
SR2BR 4.00GHZ
L533B052
ASUS
MAXIMUS VIII IMPACT
DIMM A1
DIMM B1

2

A GLIMPSE INTO THE FUTURE

WHEN YOU INSTALL THE MOTHERBOARD, you have to push the rear I/O panel into the I/O shield. This can be a struggle in some builds: You must line up all the ports with the shield, while preparing to secure the motherboard to the brass stand-offs with screws. A magnetic screwdriver makes this easier, but it can still be a pain. After we installed the Maximus VIII Impact, we looked at the back panel. We knew the motherboard came with USB 3.1 and USB Type-C, but the lack of USB 2.0 ports is odd. It's a signal that the old standard will fade away as motherboards evolve. The board offers a few other cool features. The error code LCD is visible on the rear panel, so you don't have to crack open the case to diagnose boot problems, and the audio ports on the Maximus light up with color-coded LEDs, making connecting your headphones in the dark a cinch.

3

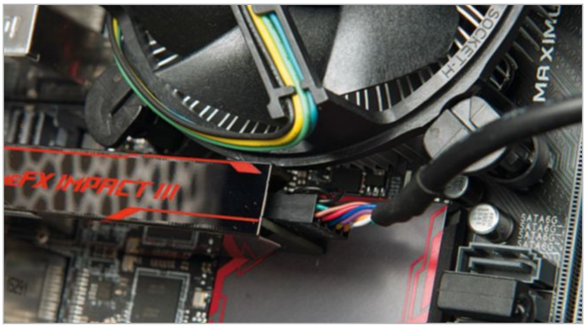
THE DARK SIDE OF USB 3

AT FIRST IT SOUNDS GREAT: All USB 3, all the time. Speed, speed, speed! "What's that? I can't hear you over the sound of my blazing-fast file transfer," we imagine ourselves saying. "Oh, we have to install a CPU cooler? No problem, let's find the USB 2.0 pins… Wait a minute." The i7-6700K doesn't come with a cooler. Most of the time, that's no big deal. We tend to use big air coolers or closed-loop water coolers on K-SKU CPUs. But as we went to install a Corsair H80i, we noticed that there are no USB 2.0 pinouts on the motherboard. Problem. When we tried to switch to an aftermarket air cooler, none of them fitted between our RAM, the audio module, and the big row of capacitors just north of the CPU. We were left with finding an Intel OEM cooler. While it's not as sexy as a water cooler, Intel coolers generally do OK, and even allow for a little overclocking when done with care.

4

BRING THE NOISE

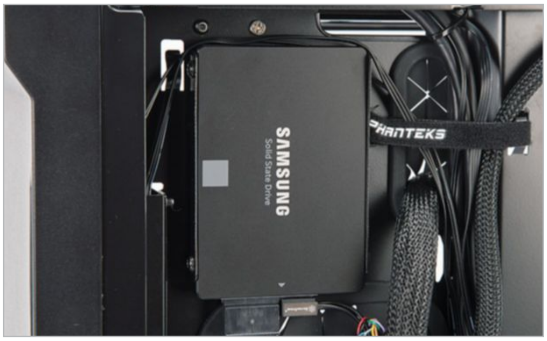
WITH MOST MOTHERBOARDS, onboard audio can seem very basic, and most of the time it is. But in a world where a motherboard is going to offer many of the same core features as a competitor (USB 3.0, RAID, UEFI BIOS), audio is one way motherboards can set themselves apart. One of the great things about the Maximus VIII Impact is that it brings a very respectable sound package. What you normally get with onboard audio is a run-of-the-mill Realtek chip. Asus decided to use an ESS ES9023P DAC instead. The audio board sits on its own dedicated (and shielded) PCB, away from other components. This can help ensure that EM noise doesn't distort the audio. This separation comes at a price, though: The audio module's PCB basically creates a wall that makes it harder to install larger aftermarket CPU coolers. In fact, we had a hard time attempting to attach any aftermarket heatsink to the CPU with this thing in the way.



5

HELLO, OLD FRIEND

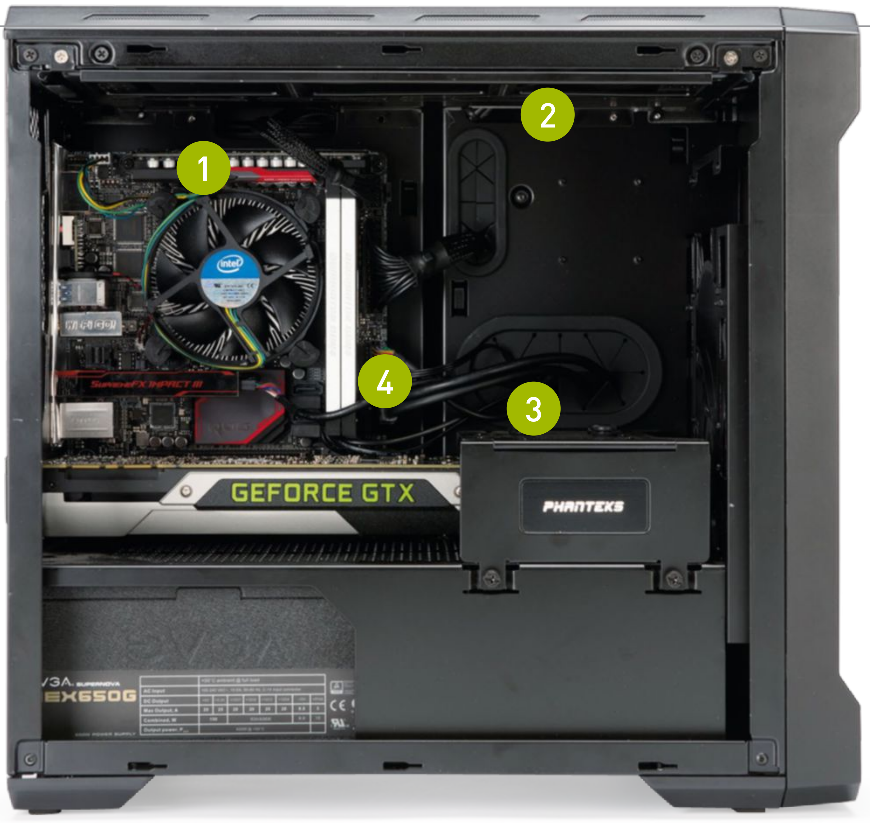
IT'S BEEN A WHILE since we used a 2.5-inch Samsung 850 Evo in a build. The M.2 versions have the same spec for speed, have less cabling to worry about, and take up less room. But the Maximus VIII Impact lacks an M.2 connector, forcing us back into the old 2.5-inch form factor. It's not so bad. The Phanteks Enthoo Evolv has a few places to mount an SSD that are elegant and out of the way. We could have mounted the drive in the motherboard compartment on top of the guard that covers up part of the video card, but we decided to put it on the back panel instead. We had two reasons for this: It's one less thing to obstruct air flow, which we needed due to a lack of water cooling for the CPU. And it allowed us to use a single SATA power cable, instead of having to route a second one to the front of the case.



6

OUT OF SIGHT, OUT OF MIND

ONE OF THE WAYS we tried to keep our storage's footprint as small as possible was to use some really thin cables. We had some thin SATA cables from SilverStone lying around, so we decided to put them to good use. If there was one problem with using these, it was that the cables came out of the sides of the connectors. While this wouldn't be a big deal in other configurations, it made for a tight fit on the Maximus VIII. The SATA connectors on the motherboard are right next to the RAM slots, so our connectors ended up being pushed up against the RAM DIMMs when they were inserted. This also made for tricky RAM installation, since the wires could easily get in the way. It wasn't until testing that we noticed that the left DIMM wasn't fully inserted, and was slightly obstructed from being fully seated due to one of the cables. It was easily fixed, but annoying, nonetheless.



1 Asus's Impact Power PCB may help regulate power for the motherboard's components, but it sure did get in the way when we tried to install our CPU coolers.

2 The Enthoo Evolv has plenty of room for a 120mm or 140mm CPU cooler, with a removable rack at the top for easy mounting.

3 While we mounted our SSD in the back, there's an alternate option to mount a drive up front.

4 USB 3.0 is a great thing, but the Maximus VIII Impact didn't give us any USB 2.0 ports to power a water-cooling pump.

LOW ON PRESSURE

BUILDING THIS RIG represented more than just a dive into VR gaming. It was also a look at what the current state of gaming hardware looks like as we start out 2016.

Without jumping up to Haswell-E, this combination of parts is the benchmark of what most single-GPU gaming systems might look like. While we would have liked to have water cooling for our 6700K, the CPU did just fine.

In terms of graphics, the GeForce GTX 980 Ti is our current top pick. While we love the Titan X's raw power, the 980 Ti offers significant amounts of power that can take just about anything you throw at it, save for aggressive antialiasing at 4K resolutions.

So how did we do at the races? Just fine, thanks. The GTX 980 Ti can't compete with three GTX 980s by itself, but showed impressive numbers when gaming at 4K.

In our two 4K tests, *Tomb Raider* and *Lord of the Rings: Shadow of Mordor*, we found an impressive frame rate that hit the mid-40s in both titles. Keep in mind that these are run at maximum settings, so antialiasing is running full-clip. If you plan on gaming on a 4K monitor that has adequate pixel density, antialiasing can be turned down (or off), which will yield big improvements in frame rates.

The rig also performed admirably in 3DMark Fire Strike Ultra. At just under 4,000, the score is about half that of our zero-point. Not bad, when the zero-point rig sports three GPUs, and twice the CPU cores with its Haswell-E i7-5960X. Considering that this CPU is half the price of what's in the other rig, the performance is what we'd expect. It's also helpful to keep in mind that a gaming PC with the Oculus Rift–recommended spec claims a score of just 2,596 on the same benchmark. Our score of 3,923 bests the recommended spec's score by 1,327, or 51.1 percent.

In our timed benchmarks, the Skylake i7 still pulled ahead of the Haswell-E 5960X in single-core performance, but only just. Cores count for a lot when encoding and editing video, which showed in the x264 benchmark. The Haswell-E's eight cores beat the smaller Skylake by 39 percent—but bear in mind that the 5960X is a $1,000 part.

All said, we're quite happy with this rig. While the motherboard proved to be a little frustrating with its layout and features, this little machine would be right at home with any gamer who wants to play the latest titles.

The year is still young, and we're likely to see a lot of new architectures and product announcements. But right now, this combination of CPU and GPU is the best you'll find that isn't on the X99 platform. ⏻

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	806	601 (25.4%)
ProShow Producer 5.0 (sec)	1,472	1,425 (3.1%)
x264 HD 5.0 (fps)	33.8	20.58 (-39.1%)
Batman: Arkham City 1440p (fps)	204	116 (-43.1%)
Tomb Raider 2160p (fps)	87.5	43.5 (-50.3%)
Shadow of Mordor 2160p (fps)	70.1	46.92 (-33.1%)
3DMark Fire Strike Ultra	8,016	3,923 (-51.1%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our desktop zero-point PC uses a 5960X CPU, three GTX 980s, and 16GB RAM. *Arkham City* tested at 2560x1440 max settings with PhysX off; *Tomb Raider* at Ultimate settings; *Shadow of Mordor* at Max settings.

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REVIEWS

TESTED. REVIEWED. VERDICTIZED.

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HP SPECTRE X2
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HP Spectre x2

For those who want a Surface Pro, but can't afford one

NOW THAT MICROSOFT'S Surface Pro computers are catching some hype, HP is jumping on the bandwagon with its own convertible. Meet the HP Spectre x2. In many respects, it's similar to the Surface Pro 4 we reviewed in the February issue. It's a 12-inch Windows 10 tablet, with a kickstand and detachable keyboard. You can also buy a stylus for more input choices. But perhaps the biggest difference is in price. The unit we tested has a $1,150 price tag, which is $300 cheaper than the Surface Pro 4 we reviewed. Unfortunately, while this may sound great on paper, the

HP Welcome
Search the web and Windows

Unlike Microsoft, HP actually includes the keyboard.

Spectre x2 makes some compromises that help explain its more affordable price tag.

The Surface Pro 4 uses a super-sharp 2736x1824 resolution panel; HP opts for a more conservative 1920x1280. To the left of the HP's screen, there's a volume rocker and a USB type-C port. To the right of the screen are ports for a SIM card and microSD card. We didn't like that you need to use a needle to get these two ports open, though. Finally, the last port is another USB type-C slot. If you've done the math, you'll notice that we made no mention of any USB type-A slots. Yep, the x2 doesn't include one. The company did this to accommodate for the thin form factor. While the 1cm-thick chassis is nice, we would have preferred HP to make the convertible a little thicker to house at least one type-A port. HP does include a USB type-A converter, although it feels a little janky to have it dangling off the side of the tablet when not in use.

Despite the thinness, the x2 is about a pound heavier than the Surface Pro 4. At 3.4 pounds, however, it's still not super-heavy. We didn't care too much for the x2's kickstand; in order to get it to pop out of the back, you have to press down on a physical switch to unlatch it. While this is a little annoying, perhaps the biggest annoyance here is that you can't get the screen to stand straight up or bend forward. The way the stand is set up, you have to lean it back a little. This is especially annoying if you want to lean it forward while watching movies in bed. And the times we did use it in bed, the x2 had the habit of occasionally falling on its back. Fortunately, it comes with a good keyboard, which snaps on easily via a strong magnet, and the keys are about as comfortable to type on as any Ultrabook. We weren't as enamored with the trackpad, though, which is really wide and often couldn't distinguish right clicks from left. It also required a little more actuation force than we would have liked. Finally, rounding out the design are the speakers by Bang & Olufsen, which we felt could use a little more volume firepower.

A QUIET LIFE

Our x2 unit rocks a 1.2GHz Intel Core M7-6Y75 along with 8GB of DDR3 RAM. The CPU is only a dual-core/four-thread part that carries a 1.2GHz base clock. While that doesn't sound too enticing, it is a 4.5-watt Skylake chip that is passively cooled, which makes it silent.

In terms of actual performance, you can probably surmise that it's not ultra powerful. Because its form factor is so similar to Microsoft's Surface Pro 4, we decided we would use that as our zero-point for testing. Now, we don't expect it to best Microsoft's convertible, considering our Surface Pro 4 cost $1,430 and uses a 2.4GHz Intel Core i5-6300 CPU, but it should give you a good point of reference. In single-threaded CPU tests, the x2 ran around 20 percent slower compared to the Surface, and lagged behind in the mid-30s against Microsoft's solution. In graphics, the x2 saw similar 25–30 percent losses. One benefit of going with a low TDP part, however, is battery life. Here, the x2 showed a 20 percent longevity boost over the Surface, with the device lasting 325 minutes in our run-down test. Boot-up time was also great, with the convertible launching in 14.6 seconds.

In the end, the x2 certainly has its blemishes, but if you're in the market for a Surface Pro 4–style device, and can't afford Microsoft's version, the x2 can get the job done for a much lower price. **–JIMMY THANG**

VERDICT
8

HP Spectre x2

⊞ **X2** Good value; quiet; good battery life.

⊟ **X-MEN: THE LAST STAND** No integrated USB type-A port; performance not great; kickstand solution needs work.

$1,150, www.hp.com

SPECIFICATIONS

CPU	1.2GHz Intel Core M7-6Y75
RAM	8GB
Display	12-inch 1920x1080 IPS
Storage	256GB SSD
Connectivity	2x USB C, microSD card reader, headphone jack, 802.11a/b/g/n, Bluetooth 4.0
Tablet/ Laptop	2.7 lb/3.4 lb

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	1,447	1,884 (-23.2%)
Proshow Producer 5 (sec)	2,343	2,947 (-20.5%)
x264 HD 5.0	7	4.4 (-37.1%)
Tomb Raider (fps)	33.4	23.6 (-29.3%)
3DMark 11 Perf	1,575	1,182 (-25%)
Battery Life (min)	270	325 (20.4%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point is Microsoft's Surface Pro 4 with a 2.4GHz Intel Core i5-6300U CPU and 8GB of RAM, running Windows 10 64-bit. 3DMark 11 was run in Performance mode; *Tomb Raider* was run using low settings.

Sager NP8675-S

An engineering marvel

WHEN NVIDIA TOLD US that it managed to shrink its desktop GTX 980 GPU to fit inside notebooks, we went through two stages of denial. The first was disbelief: "The 980 is a huge and powerful card," we thought. The second stage was dismissiveness: "It's got to throttle tremendously." To prove us wrong and to fan the flames of hardware absurdity, Sager armed its NP8675 gaming notebook (seriously, who names these things?) with both a desktop 980 and a high-end Core i7-6700K Skylake desktop CPU.

Surprisingly, 980 GPU performance wasn't throttled.

On paper, it's an abomination of a laptop, but it actually friggin' works.

Of course, if you're going to squeeze desktop components into a laptop chassis, you shouldn't expect an ultra-portable package. The Sager here is of the big, bulky 17-inch variety, and it has a hefty 14-pound carry weight to match its size. If there's one criticism we could levy against Sager in the past, is that its gaming notebooks were very bland-looking, but there are a few aesthetic bells and whistles this time. In addition to the nice silver Sager logo on the back, there are some pulsating LEDs, which add a little bling (if you're into that). The chassis also has some sharp lines and edges, giving it a slightly futuristic look.

More exciting is the 1080p display. While we would have preferred a 1440p screen, the monitor here uses a 75Hz IPS panel that supports G-Sync. That's a lot of cool display tech in one sentence. The rest of the design is good. The speakers by Sound Blaster are competent, the LED-backlit keyboard offers some nice travel, and the trackpad is solid with two discrete click buttons and a fingerprint reader. The notebook also sports enough ports to warrant its "desktop-replacement" label, including: two Ethernet, five USB 3.0, one USB Type-C, two DisplayPort, an SD card reader, and an HDMI port.

But you probably aren't reading this review to hear about the laptop's ports. "How well does it perform?" you're probably screaming. Cool your jets, we're getting there. The 980 outfitted here has the same 256-bit memory interface width and 224GB/s memory bandwidth as its desktop sibling. One advantage that it has over Nvidia's discrete card is double the VRAM. Your reference 980 has 4GB VRAM, whereas this card rocks 8GB. Considering that the notebook is relegated to a 1080p panel, you'd be hard-pressed to actually use up all that VRAM (or anything near it), but it's still nice to have. Compared to our Alienware ZP laptop, which is getting long in the tooth with its GTX 765M GPU, we saw a 106–234 percent performance delta in our graphics benchmarks. It's really not a fair comparison at this point, so we decided to see how it stacks up against the 3DMark 11 Extreme numbers we ran on CyberPower's Syber Vapor system we reviewed last year. If you'll recall, the Vapor rocked a 4790K and GTX 980 desktop card in a small Mini-ITX chassis, which makes it a fair comparison point for the Sager.

MAGIC NUMBERS

The results? The Sager not only performed on par with the desktop PC, but actually ran 3 percent better. Older drivers on the Vapor could explain some of this delta, but still, getting anywhere near close to the desktop card in this form factor is insane. Consider us believers in this Nvidia voodoo. CPU performance was also great. We saw up to an 11 percent increase in single-threaded CPU tests compared to our ZP laptop's Core i7-4700MQ laptop proc. In multithreaded tests, we saw a huge 43 percent difference. Yes, it did get a little loud under load, but it's running top-tier desktop parts in a laptop chassis, so what do you expect?

One performance hurdle that we ran into pertained to boot times. It took roughly 25 seconds to reach Windows, despite the notebook using a premium Samsung 850 Evo SSD. Sager tells us that this is because the gaming notebook has so many built-in peripherals for the drive to check, so it takes a little longer. That seems fair.

At $2,850, you'll be paying a high price for this kind of performance, but at the same time, it's kind of an engineering marvel. To get this much power out of a chassis of this size boggles the mind. You can max out pretty much any game at 75fps here. Whether you're looking for a high-end gaming system, editing rig, or VR machine on the go, the Sager NP8675-S has you covered. It might not be cheap, but it's still definitely Kick-Ass. **–JIMMY THANG**

VERDICT
9
KICK ASS!

Sager NP8675-S

+ GTX 980 Desktop CPU and GPU performance; G-Sync, IPS, high-refresh-rate monitor.

– GTX 980M Not very portable; gets a little loud under load.

$2,850, www.sagernotebook.com

SPECIFICATIONS

CPU	Intel 4GHz Core i7-6700K
RAM	16GB of DDR4/2,133MHz
Chipset	Intel Z170
GPU	Nvidia GeForce GTX 980 8GB
Display	17.3-inch, 1920x1080 display (matte)
Connectivity	5x USB 3.0, headset and mic port, SD card reader, 2x Mini DisplayPort, HDMI port, 2x Ethernet port, fingerprint reader, USB Type-C
Storage	250GB SSD, 1TB HDD
Weight (Lap/Carry)	10 lb, 1.6 oz /14 lb 14.4 oz

BENCHMARKS

	ZERO-POINT	
Stitch.Efx 2.0 (sec)	962	970 (-0.8%)
Proshow Producer 5 (sec)	1,629	1,459 (11.7%)
x264 HD 5.0	13.5	19.4 (43.7%)
Bioshock Infinite (fps)	36.1	74.6 (106.6%)
Metro: Last Light (fps)	30.4	74.6 (145.4%)
3DMark 11 Perf	4,170	13,926 (234%)
Battery Life (min)	234	124 (-47%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point notebook is an Alienware 14 with a 2.4GHz Intel Core i7-4700MQ, 16GB DDR3/1600, 256GB mSATA SSD, 750GB 5,400rpm HDD, a GeForce GTX 765M, and Windows 7 Home Premium 64-bit. *BioShock Infinite* tested at 1920x1080 at Ultra DX11 settings; *Metro: Last Light* tested at 1920x1080 at DX11 medium quality settings with PhysX disabled.

Crucial BX200 960GB

An old-school SATA drive in a PCI Express world

THESE ARE EXCITING TIMES in data storage. That's right, storage is exciting. For proof, observe exhibit A, namely the introduction of much faster PCI Express interfaces for PC hard drives. Exhibit B involves radical new memory technologies, such as Intel and Micron's 3D XPoint. Case closed?

Certainly, the overall upshot is that storage is moving from what you might call the megabyte era into the gigabyte era, in terms of bandwidth or data shunted every second. In that context, what to make of a new SSD from Crucial (the retail front of the aforementioned Micron), which is based on the ancient SATA interface, and looks decidedly non-exotic on paper?

Luckily for Crucial, there's a counter argument to all of the above, and it involves diminishing returns. Rig up two otherwise identical PCs, one with a conventional but best-of-breed SATA SSD, and one with a newfangled PCI Express puppy, and it's usually difficult to pick them apart subjectively. The SATA system feels pretty much as snappy. Ultimately, isn't that what counts? How your PC feels, as opposed to somewhat arbitrary benchmark numbers?

A lot of the time, yes, even if there are heavy duty applications such as high-end image-editing that sometimes provide greater contrast. Anyway, the point is that if the new Crucial BX200, seen here in 960GB specification, is a solid SATA SSD, it's going to be good enough for most of us most of the time. Factor in the competitive pricing, and the appeal of a near 1TB solid-state drive is obvious enough.

EXECUTIVE SWEET

It doesn't hurt that Crucial's Storage Executive SSD management software is so slick. It runs in a browser, has a clean and intuitive interface, and gives quick and easy access to features such as firmware updates (neither data destructive nor requiring a reboot) and resetting the drive to factory state. The last point being particularly handy if one of your work colleagues has set the thing up with some very odd partitioning that you can't easily undo within Windows. Naming no names.

The problem, however, is that this isn't a terribly good SATA SSD. You wouldn't necessarily spot that from most of the benchmarks. The headline results from ATTO and AS SSD look decent enough. However, and as a for instance, the detailed ATTO results show some fairly dramatic inconsistencies. Some test results are great, others significantly less so.

More relevant are the real-world file compression and copy benchmarks, that show the BX200 miles off the pace of the opposition. And remember, that opposition is conventional SATA drives. A good PCI Express drive would tear the BX200 a new one. Indeed, during our pre-benchmark setup procedure, the BX200 just felt slow.

So while we could drill down into details such as the BX200's Silicon Motion SM2256 controller chipset or its triple-level TLC memory cells, contrast them with the Marvell 88SS9189 controller and MLC NAND in Crucial's quicker MX200, and discuss how it feeds into the disappointing performance, it's probably futile.

Instead, better to invoke the sister cliché to the diminishing returns spiel we trotted out earlier. Yup, it's ye olde false economy. The BX200 is cheaper than many similarly sized SATA SSDs, including Crucial's own MX200, but you'll end up wishing you'd spent that little bit more. **–JEREMY LAIRD**

BENCHMARKS

	Crucial BX200 960GB	OCZ Trion 960GB	Samsung 850 Pro 2TB
AS SSD Sequential Read (MB/s)	501	**513**	**513**
AS SSD Sequential Write (MB/s)	453	436	**499**
AS SSD 4k Random Read (MB/s)	28	31	**41**
AS SSD 4k Random Write (MB/s)	109	92	**126**
ATTO Sequential Read (MB/s)	559	**564**	404
ATTO Sequential Write (MB/s)	492	**517**	427
5GB Zip Compression (secs)	195	**194**	**194**
30GB Internal File Copy (secs)	382	263	**160**

Best scores are in bold. The test platform consists of an Intel Core i7-6700K, Asus Maximus VIII Formula, and 2x 8GB Corsair Vengeance LPX DDR4-2400.

VERDICT 6

Crucial BX200 960GB

⊞ **BLOCKBUSTER** Competitive pricing; plenty of capacity; nice software.

⊟ **BALL-BUSTER** Incredibly patchy performance; you'll wish you paid a little bit more.

$299, www.crucial.com

SPECIFICATIONS

Capacity	960GB
Chipset	Silicon Motion SM2256
Memory	Micron 16nm TLC NAND
Sequential	540MB/s read, 490MB/s write
IOPS	66k read, 78k write
Warranty	Three years

Mad Catz RAT Pro X

You don't have to be Mad Catz to make it but it helps

THE QUESTION of how many dpi is "enough" is one that's been batted around by tech companies for as long as we've had optical mice. Whether it's 800, 1,600, 5,000, or more, everyone has an opinion—and it often coincides with the maximum sensitivity of whatever pointing device they're trying to sell you at the time.

Mad Catz—a company that doesn't so much scratch the technological itches of prospective purchasers as leave them tearing at their heads with a baffled expression on their faces—thinks that it has solved the dpi conundrum once and for all, and invites you to splash the price of a GTX 960 on… a mouse with an interchangeable sensor.

Three sensors are available at launch. Ours came with a 5,000 dpi, 3.3m/s, PixArt PWM 3310 optical sensor, about which we have no complaints, and they all snap into place rather satisfyingly as long as you get the alignment right. Magnets then hold the sensor tight against a retractable pin-grid array, which is just asking to be bent if you're the type of person who can't resist taking things apart multiple times to shove them under your buddy's nose, shouting, "Look how cool this is!"

Two laser sensors are also available, both topping out at 8,200 dpi: a Philips Twin-Eye, with a tracking speed of up to 6m/s, and a PixArt model that can do 3.8m/s. All models cost the same, and the idea is that, when the quantum mouse and the X-ray sensor are invented, Mad Catz can release an updated module, so you don't have to give up your five-year-old, hand-gunk-filled mouse body in order to upgrade. (Early experiments with quantum mice have been unsuccessful as they can't know where they are and how fast they're going at the same time.)

Each module can store nine profiles, set using the PC software, with an LED display showing which you've selected. There are no fancy lighting effects on the body, although it is such a horrific livid lime green color, you're not going to lose it in a hurry, even in the dingiest of dens.

The mouse body is made from a magnesium alloy, leading Mad Catz to label this its lightest and strongest gaming mouse. If you prefer a heavier device or like your weight distributed differently, you're out of luck, because there's no ability to add more mass. And it certainly is light—what you at first think is going to be a heavy metal frame feels so insubstantial it could be made of plastic, until you squeeze it. The buttons and wheel really are plastic, however, and have been left feeling a little flimsy in the race to shave off ounces.

Prior experience with RATs tells us it'll probably be fine, and surely no one would design a future-proof mouse without giving thought to the longevity of the rest of the body.

WHEELY GOOD

The wheel is also swappable, with three options included in the box. Flipping the wheel up prior to replacement looks like something from *Robot Wars*—a circular saw blade poised to smash down on the competition—but we found the thickest wheel to be the best in use, with its positive click and the thunks as it rotated leaving no ambiguity about what you've just done. The whole wheel assembly pivots left and right, adding an analog dimension to strafing controls—a really nice touch.

The rest of the body is customizable, too, as is RAT tradition. A small tool is included to adjust bolts (along with a cleaning brush for that hand-gunk), and the palm rest can be raised so high it almost looks like a dragster version of a Lamborghini Veneno. Even with this, however, we found it a little small for our meaty hands, and a few more millimeters in height would have done it a lot of good. Replaceable plastic and ceramic plates, attached by magnets, live underneath, providing a low-friction slide over most surfaces.

If you love RATs, and never want to use anything else, this is for you. For anyone else, approach with caution and consider the RAT 9—it's half the price. –IAN EVENDEN

VERDICT 8

Mad Catz RAT Pro X

+ **POTENT** Strong and light; choice of different sensors; highly adjustable.

− **RODENT** Horrible color; bit too small; possibly too light.

$200, http://madcatz.com

SPECIFICATIONS

Sensor	PixArt PWM 3310
DPI	5,000 dpi
Buttons	10
Weight	5 oz
Connectivity	USB

Samsung 950 Pro 512GB

Now you're cooking with fire

IMAGINE FOR A MOMENT that you're the manager of a fine restaurant known as your PC, and for the sake of analogies, your storage subsystem is the kitchen area. If you're using a hard drive, it's like having an overworked short-order cook running the show, and to make matters worse, he has arthritis. You could add a second cook to help out (RAID 0), but he also has arthritis, and the diners are getting restless.

Moving to an SSD is like upgrading from your arthritic cook to a world-class chef, who also happens to be hopped up on speed. What's amazing is that orders are prepared in record time, in a smaller kitchen, all while never dropping any food or dishes. Everyone is happy, and the new chef is easily worth his salary—which happens to be 10 times what you were paying the short-order cook. Also, the smaller kitchen area sometimes runs out of food before the night is done.

We can carry the analogy too far, but the point is that SSDs are super-fast compared to hard drives. And NVMe gooses chefs to perform even greater feats of culinary delight, with their own lingo that helps chefs communicate more effectively with their staff. They're overkill if you're running a small diner, but if your PC is a popular five-star restaurant, they're amazing.

Last year, Samsung's 950 Pro became the first retail M.2 NVMe drive to hit the streets. The 256GB model (Holiday 2015, p.80) was fast while being more affordable than the competition, but we wanted to test the 512GB model. Unlike hard drives, SSDs benefit tremendously from increased parallelism, so by doubling the capacity, Samsung also doubles the number of NAND chips. That means it's better able to keep humming along at top speed, and as a bonus, it has a lower price per GB.

TOO HOT TO HANDLE

Samsung's 950 Pro 512GB is easily the fastest M.2 SSD we've tested, beating the 256GB version by 25 percent overall. Intel's 1.2TB SSD 750 is a little faster in some tests, but the 950 Pro can go places the SSD 750 can't—specifically, laptops. If you have a modern laptop, you could upgrade from the weak-sauce 128GB drives so many OEMs still insist on using to a healthy half-terabyte. That's more than enough room for a bunch of games, movies, your music collection, and several thousand photos—with room to spare.

All that speed does have a dark side, however: At times, the controller needs to throttle to keep temperatures in check. We tested with and without a fan blowing across the SSD. The cooling improves peak performance by up to 30 percent in heavy workloads, with overall performance improving nearly 10 percent. But that's no fly in the soup; the 950 Pro is so fast that storage is no longer a bottleneck.

Do you need this much performance? Perhaps not. But if you've covered all your other bases and have cash to burn, this tiny chef stands ready to overhaul your kitchen in ways you never thought possible. Until the next wave of M.2 NVMe drives arrives later this year, along with a 1TB model of the 950 Pro, this is the current king of the SSD mountain. –**JARRED WALTON**

VERDICT
9
KICK ASS!

Samsung 950 Pro 512GB

+ FLAMETHROWER Great performance; compact form factor; power-efficient; lowest price per GB for NVMe.

– FLAMEOUT Can throttle at times; needs M.2 NVMe support to use as a boot drive; where's the 1TB model?

$350, www.samsung.com

BENCHMARKS

	Samsung 950 Pro NVMe 512GB	Samsung 950 Pro 512GB *No Fan*	Intel SSD 750 NVMe 1.2TB	Samsung 950 Pro NVMe 256GB	Kingston HyperX Predator 480GB	Samsung 850 Pro 1TB
AS SSD Sequential Read/Write	2,176/**1,474**	2,162/1,360	**2,362**/1,320	2,063/901	1,008/743	527/496
AS SSD Random Read/Write	**53**/178	52/158	36/**205**	52/160	39/92	37/110
AS SSD QD64 Random Read/Write	1,144/382	1,142/319	**1,446/1,041**	1,021/254	446/247	352/279
IOmeter Mixed Read/Write Sequential	1,570	1,231	**1,605**	1,008	580	502
IOmeter Mixed Read/Write Random	388	361	**454**	267	84	180
File Copy (20GB)	**672**	623	564	560	429	242
PCMark 8 Storage Score/Bandwidth	**5,100/743**	5,099/730	5,069/511	5,089/622	5,010/324	4,987/284

Best scores are in bold; all figures except PCMark 8 Score are in MB/s. The test platform consists of an Intel Core i7-6700K processor, Asus Z170-A mobo, and 2x 8GB G.Skill DDR4-3000.

SPECIFICATIONS

Interface	M.2 PCIe x4 Gen3
Form Factor	M.2 2280
Capacity	512GB
Controller	Samsung UBX
Memory Type	Samsung V-NAND
Max IOPS Read/Write	300,000/110,000
Endurance	400TB
Warranty	Five years

Gigabyte 980 Ti Gaming-6GD

Rigged for silent running

SOMETIMES THE MOST powerful weapons aren't the biggest and loudest; ballistic submarines can wipe out dozens of cities, and part of their arsenal is the ability to quietly sneak up on unsuspecting targets. Gigabyte's Gaming-6GD graphics card takes a similar approach, by disabling the fans when they're not needed, allowing for a truly silent GPU most of the time.

The card makes some noise when gaming, of course, particularly if you push the overclocks, but it's a few decibels quieter than our stock 980 Ti. And that's with the side of our case removed and our SPL meter 5cm from the GPU; close the case, and the other components usually make far more noise than this quiet GPU.

There are compromises made to get here, such as the rather large 12-inch PCB—putting the card in a standard ATX case required the removal of one of the drive cages. This is also an open-air cooler, so it will vent heat into your case, where blowers help by exhausting air. Unlike Zotac's ginormous Amp! Extreme (January 2016, p80), at least this is a dual-slot card, meaning with the right motherboard and case, you could use three or even four of the cards in SLI. Or you could take the sensible approach and use one or two cards, and still have space for a PCIe SSD.

SILENT BUT DEADLY

Being able to run silently doesn't mean this is a namby-pamby card that will struggle when you fire up a game. No, this is still a fully enabled GTX 980 Ti, complete with a factory overclock of 152MHz on the core—or 190MHz when you enable the OC mode in Gigabyte's OC Guru utility. That's only scratching the surface of what this card can do, as further tuning enabled us to push the base core clock to 1,255MHz, with the GDDR5 running at 8Gb/s. Gigabyte's factory overclock boosts performance 11 percent over stock, and OC mode gives a few percent more. Manual tuning enabled an additional 11 percent improvement, though we've seen similar results from every other 980 Ti we've tested.

Technically, Zotac still holds the performance crown with its triple-wide monstrosity but, thankfully, you're not paying extra for a factory overclock you could achieve on your own. In fact, the Gigabyte card has the same MSRP as a standard 980 Ti, with frequent sales and rebates bringing the cost down to $630 or less. As a bonus, select retailers are currently including a free copy of the new *Rise of the Tomb Raider* (reviewed p90) with the card, worth $50.

While we wait for FinFET GPUs to appear, the 980 Ti continues its reign as the best high-end GPU. Thanks to factory overclocks and custom cooling, Gigabyte's card is even faster than the mighty Titan X, at roughly two-thirds the price. It's like sinking a battleship with a single well-placed torpedo. Just don't be too surprised when the next-generation destroyers retaliate later this year. –**JARRED WALTON**

VERDICT
9
KICK ASS!

Gigabyte 980 Ti Gaming-6GD

➕ **RED OCTOBER** Excellent performance; good factory overclock; quiet and effective cooling.

➖ **DOWN PERISCOPE** Large card; stock RAM clocks; 16nm FinFET is coming.

$650, www.gigabyte.com

QHD AND 4K BE

	Gigabyte 980 Ti	Zotac 980 Ti	GTX Titan X	GTX 980 Ti	R9 Fury X	R9 Nano
Batman: Arkham Origins	119/**65**	**124**/61	114/54	112/54	115/58	102/51
Grand Theft Auto V	62/52	**63/55**	58/49	58/49	50/46	46/40
Hitman: Absolution	66/33	**70/35**	64/33	64/33	64/**35**	61/33
Metro: Last Light	90/48	**92/50**	81/44	80/44	70/38	61/33
Middle-Earth: Shadow of Mordor	94/53	**98/55**	85/48	84/48	81/47	74/42
Tomb Raider	103/51	**106/53**	92/47	91/45	84/45	72/37
The Witcher 3	60/37	**63/38**	54/33	53/32	50/31	43/27
Seven-Game Average	85/48	**88/50**	78/44	77/43	73/43	66/37

Best scores are in bold. Results are average fps at 1440p/4K. Our test bed is a 4.2GHz overclocked Core i7-5930K in a Gigabyte GA-X99-UD4 motherboard, 4x 4GB G.Skill DDR4-2666, 1TB Samsung 850 Pro, and EVGA SuperNOVA 1,300W G2 running 64-bit Windows 10.

SPECIFICATIONS

GPU	GM200
Lithography	28nm
Transistor Count	8 billion
CUDA Cores	2,816
ROPs	96
Core/Boost Clock (MHz)	1,152/1,241
OC Mode Clocks (MHz)	1,190/1,279
Memory Capacity	6GB
Memory Speed	7,010Gb/s
Bus Width	384-bit
TDP	250W

Denon DA-300USB

Unequivocal audio perfection? Close

WE'RE SURE YOU'VE NOTICED by this point, but we've gone a little audio loco this issue. Yes indeedy, including this sweet little number here—the DA-300USB—this issue alone will feature no fewer than 13 different acoustic reviews. So what is it that makes this little device so important? Well, in short, it's all about completing the holy trinity of audio perfection. The Denon is a key ingredient, one that needs pouring into that mixture. In short, if you haven't already digested our first feature this issue, it's all well and good having hi-fi headphones, but if you're not powering them through a solid and dependable amp and D/A converter, you may as well not bother. That said, the Denon DA-300USB is hardly cheap—at $500, you could easily buy an AMD R9 Nano for this kind of money. So the question has to be put: What exactly goes into building a DAC like this?

Well, first you start with the hardware. This little beauty features a total of seven separate PCBs, a high-resolution Texas Instruments PCM1795 digital-analog converter, and a grand total of nine isolator chips, ensuring as little noise as possible makes it between you and your audio. All of this comes together to ensure you net yourself a nice 112dB signal-to-noise ratio for squeaky clean listening. On top of that, the DA-300USB has a frequency response between 2Hz and 100kHz, can sample music up to 24-bit 192kHz, and can decode both 2.5MHz and 5.6MHz high-resolution DSD files.

As far as connectivity goes, this isn't your standard go-to PC audio component. There's a single 6.3mm headphone jack in the front (3.5mm adapter not included), two TOSLINK/SPDIF inputs in the rear, one coaxial input, one RCA analog-out, and—more importantly for us—one USB-in (cable also not included).

It's certainly enough to drool at. Denon has been manufacturing audio equipment in Japan for well over 100 years now, and it shows. Unlike the vast majority of options out there, the Denon DA-300USB is crisp and classy, with a small overall footprint. It can be mounted horizontally or vertically, with a low-noise OLED display reorienting depending on which way you position it.

NO BASS?

But surely, all this is null and void, techno-jargon designed to lull the unsuspecting into purchasing this audio black hole? How does it actually sound? That depends on what you're using to test it with. For our testing purposes, we used a combination of different headsets, ranging from $25 Sennheiser ear-buds, all the way up to $400 Oppo PM-3s. Overall, we found the soundscape was deep, crisp, and clear. Classical and epic scores benefitted most, not suffering from any muffling, thanks to overpowering bass vibrations. It was a joy to listen to. Punk, metal, and synthetic music (here's looking at you, dubstep), on the other hand, took a minor step back. As these generally tend to be quite bass-dependent, they weren't as enjoyable here as on Creative's Sound Blaster X7. That's not to say it was a terrible experience, as the DA-300USB has a habit of erring on the side of tone as opposed to bass vibration. However, it was a similar story in gaming—the treble and mids were crisp, and the lower third was warm. Warm enough to enjoy, but if you're looking to blow your eardrums up with those luscious ludicrous low-frequency explosive vibrations, you're going to be a little disappointed, especially for this kind of money. Other downsides? The DA-300USB doesn't come with a USB 2.0 cable as standard, and it doesn't come with a 6.3mm-to-4.5mm adapter either.

The DA-300USB has a lot to say for itself—it's a $500 music lover's dream. If you're into high-quality music and sound, the DA-300USB is the device for you. But if you're more of a gamer, ready to spend a weekend fragging noobs listening to Deadmau5, you're probably going to be better off with Creative's X7 Sound Blaster instead. **–ZAK STOREY**

VERDICT **8**

Denon DA-300USB

⊞ **ARIA** Plug and play; crisp and well-rounded soundscape; strong SNR; classy looking device.

⊟ **DIRGE** Pricey; no included adapter/cable; could be bassier; no software package.

$500, www.denon.com

SPECIFICATIONS

DAC	Texas Instruments PCM1795
Signal-to-Noise Ratio	112dB
Headphone Amp	50mW, 32 Ohms
Connectivity	1x 6.3mm headphone jack; USB 2.0-in; TOSLINK/SPDIF-out; coaxial-out; RCA analog-out
Dimensions (WxHxD)	4.5x6.9x7.2 inches

Audio. Audio, everywhere.

Corsair Carbide 400C

Mobos the right way round? What next?

WE HAD A LOT OF GOOD things to say about the 600C when we reviewed it last issue. It was a chassis that addressed a lot of concerns we'd started to see in some of Corsair's more traditional Obsidian lineup. And it managed this without necessarily losing any of that sleek elegance Corsair cases are known for. So what does the 400C bring to the table that the 600C couldn't? Does it extend beyond the simple fact of it being the normal, not-inverted version? Well, yes actually, and in a lot of ways, it makes it somewhat more appealing.

Immediately out of the box you'll notice this chassis is considerably smaller than its older brother. In fact, it's quite noticeable—losing three inches in length, one inch in height, and two inches in depth, it has a smaller overall footprint; not a bad thing. The two 5.25-inch bays found on the 600C have disappeared entirely, no doubt thanks to the standardized ATX layout the 400C sports. What this means is that there's no front door panel either; in fact, all you get is a solid front panel instead, a nice step into 2016. Let's be honest here, in the world of high-speed internet and cloud storage, do we really need a CD drive any more? Even portable ones are becoming harder and harder to justify.

NICER, NEATER, SMOOTHER

What is interesting is how this case feels. It's tidier and neater than the 600C, and it looks and feels classier. Perhaps it's because of that step back to the more commonplace standard ATX layout—either way, it just looks gorgeous. The powder-coat finish inside and on the external steel panels is lovely to the touch, and has a more sandblasted feel than the usual plain black interiors we're used to seeing. And although it doesn't feature the same aluminum finish that the 600C does outside the case, the front panel hides away any fingerprint stains with ease, making it a stunning feature on your desk.

For cooling, you have access to three 120mm or two 140mm fans in the front, and an additional two 140mm fans or 120mm fans in the roof (with the obligatory 120mm in the rear for good measure): plenty of airflow to satisfy all of your desires. No doubt some of you will have concerns regarding airflow for that front panel—after all, it is very similar in a lot of ways to NZXT's H440. Fortunately, you can rest easy, because there's a solid inch of fully ventilated side cut-outs before that front panel even touches the case. You certainly won't be air-starved if you do choose the front intake route.

So what are the drawbacks? After all, this is a $100 chassis—$50 cheaper than the 600C. Well, the materials found in the 400C leave something to be desired. The panels are constructed from steel, and feel a little flimsy. That said, the windowed side panel is clean and straight, and the handle latch mechanism is second to none. When building, you can also lift the window off its hinges entirely. Otherwise, there's not a great deal of storage solutions for you to choose from, with support for a grand total of three 3.5-inch drives, and two 2.5-inch drives. And then, of course, you do lose out on that gorgeous paint job that Corsair threw on the 600C.

In other respects, it's actually far greater value for money than the 600C, and that smaller footprint simply adds to its sex appeal as far as we're concerned. If Corsair had thrown in a fan controller, constructed the chassis out of aluminum, and given us a little more cable management room in the rear of this bad boy, it would be damn near perfect for any quick AIO reference build. Not to say it wouldn't be ideal for water-cooling, because this thing is an absolute monster anyway. If you did all that, Corsair, and even slapped a $200 price tag on it, we're damn sure it would be getting an even higher score than we've awarded it today. **–ZAK STOREY**

VERDICT 8

Corsair Carbide 400C

+ **CARBONITE** Gorgeous windowed side panel; smaller footprint than the 600C; strong airflow; great value; classy.

− **MUD** It's still suffering from limited storage options.

$100, www.corsair.com

SPECIFICATIONS

Form Factor	ATX
Dimensions	13.4x16.9x15.9 inches
Cooling	Front: 3x 120mm or 2x 140mm; Rear: 1x 120mm; Top: 2x 120/140mm
CPU Cooler Clearance	7.9 inches
Graphics Card Max Length	14.6 inches
Storage Support	2x 3.5-inch HDD mounts; 3x 2.5-inch SSD mounts

Synology DiskStation DS1515

So much more than just a box of drives

WE'RE BIG FANS OF NASES—if you don't have centralized storage for all your data, you're not living in our brave new world. We looked at entry-level, two-bay NAS units in our Holiday 2015 issue (Vol. 20, No. 13), and we also looked at the wonderfully powerful QNAP TVS-EC1080+ a couple of issues ago. While it's good to have access to the very best kit, we realize that $3,000 may be beyond some budgets, which is why we're looking at this mid-range offering.

The DS1515 is a five-bay NAS, which boasts a number of impressive features that make it a tempting solution for use in a small office as well as the home. The four Gigabit Ethernet ports support Link Aggregation for speedy access as well as failover, in case a connection fails. It also boasts a hardware encryption engine, and supports the use of an SSD cache drive, useful in an office.

Setting up the DS1515 is as easy it can be: Slot your drives in place, power it on, connect it to your network, point your browser at the device, and pick the RAID setup that's best for you. You can create numerous shared folders, install an impressive array of software packages, and access the NAS over the Internet, thanks to Synology's QuickConnect system—which is an incredibly easy way to access your data when out and about.

The hot-swappable drive bays are tool-free and feature a simple but effective system for holding your 3.5-inch hard drives in place—drop your drives in the cradles, clip the side runners in place, then slot in the caddies. You'll need to reach for your screwdriver if mounting 2.5-inch drives, but that's fairly standard. The caddies have a simple lock and key to help protect the drives from inquisitive fingers, although that won't deter anyone who's serious about getting at your hard drives.

HIP, HIP, ARRAY!

We populated the unit with five Hitachi 2TB SATA Enterprise drives—not the cutting-edge helium-filled offerings we used with the QNAP TVS-EC1080+, but capable enough for this. We built a RAID 6 array, as it offers better redundancy compared to RAID 5, and is the preferred setup for this many drives. You can, of course, build RAID 0 or even eschew RAID altogether, if that's your preference. Performance was strong but not rewriting the record books.

While the hardware forms a strong foundation, it's the software that really impresses—the DiskStation Manager is incredible; calling it just a NAS feels like a disservice. Sure, it'll take care of your files like any good NAS should, but it can also act as web server, a mail manager, the heart of a comms setup, media server, and more. There are pre-compiled, easy-to-install packages for WordPress and Plex, among others, while more sober requirements are easily filled by the video, photo, and audio stations, which make organizing your media wonderfully straightforward.

It's decent value for a five-bay NAS drive with a huge list of features, but $600 is still a sizeable outlay for a device that isn't going to slash rendering times, or improve frame rates. The lack of front-accessible USB ports is a pain too—especially if you're planning on tucking the unit out of the way. The real problem, though, is the lowly processor and lack of upgradable memory—these are fine for handling simple file transfers, but start to struggle when running web servers and other more exacting packages. You can opt for the DS1515+ (which boasts an Intel Atom 64-bit CPU and more memory) if that's an issue, but it adds $200 to the price. –**ALAN DEXTER**

VERDICT 8

Synology DiskStation DS1515

➕ **STORAGE** Wonderful OS; easy setup; seamless access; stunning feature set.

➖ **SNORE-AGE** Can't upgrade memory; lowly CPU; no HDMI port.

$599, www.synology.com

BENCHMARKS

	Synology DiskStation DS1515 (RAID 6)
ATTO Read (MB/s)	118.8
ATTO Write (MB/s)	114.9
CrystalDisk Mark 5.1.1 Read (MB/s)	17.5
CrystalDisk Mark 5.1.1 Write (MB/s)	4.6
50GB Write to NAS (MB/s)	103.5
50GB Read from NAS (MB/s)	95.9

SPECIFICATIONS

CPU	Annapurna Labs Alpine AL-314
Cores	4
Speed	1.4GHz
Installed Memory	2GB DDR3
Memory Upgradable	No
OS	DSM 5.2-5644 Update 2
USB Ports	2x USB 3.0
HDMI Ports	None
Ethernet Ports	4x Gigabit
Others	2x eSATA
Warranty	Three years

The right lighting can make a handsome game look even better.

Rise of the Tomb Raider

Aloft, in the loft, sits Croft. She's not soft

DIDN'T THE TOMB RAIDER rise in the previous game? Following on from 2013's reboot, a rich kid with daddy issues once again strikes from the shadows at wandering goons. But this isn't Gotham City.

Rise begins with a trip to the mountains, which is, dare we say it, thrilling. Completely HUD-less, and with a motion-captured Lara struggling against high winds and deep snow, the only threats are falling off the edge or not getting your ice axe out in time. It's a strong, if linear, opening that moves into an actual tomb raid in Syria—Lara's one pair of pants proving resilient against heat as well as cold—then on to the Siberian wastes and the game proper, which is split between exploration and combat.

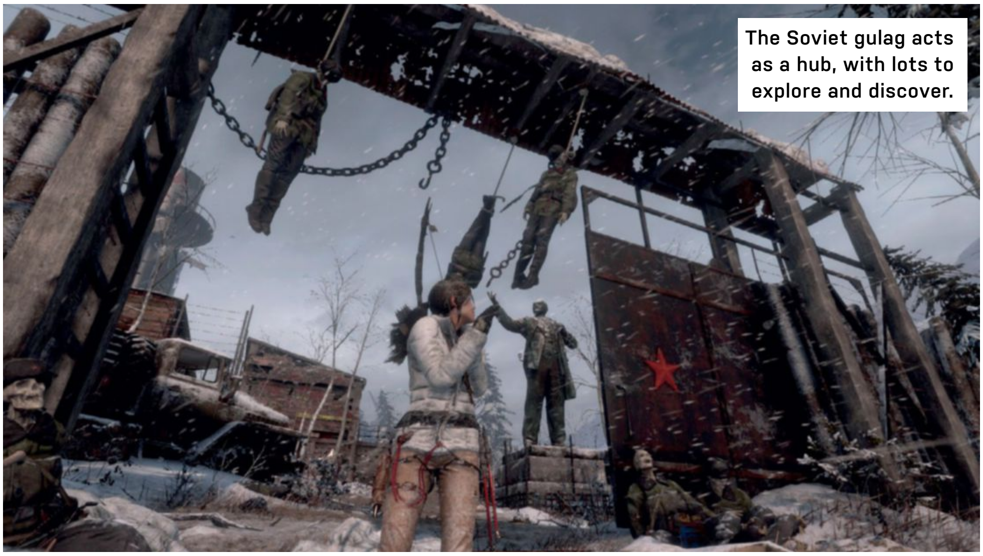
The platform and exploration sections are the best, and Lara using her knowledge and quick-thinking to get the drop on the bad guys is much more believable than the parts in which she becomes a one-woman army against heavily armed and armored opponents (although scoring headshots with a bow and arrow remains hugely satisfying.) The contrast between her slight figure with a good heart, as she pursues her goals as much out of love for her father as out of intellectual curiosity, and the mass murderer capable of choking the life out of men twice her size, setting them on fire, ambushing them with nail bombs, and bringing the roof of an ancient structure (surely priceless in its academic value) down on their heads was mentioned a few times around the launch of the first game, but it bears repeating here, because it hasn't changed.

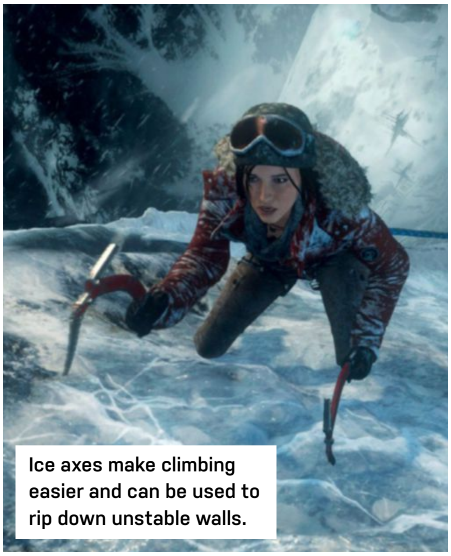
And that's not the only thing. This feels more like an expansion pack than a sequel in many ways, as you do the same awful things to the same wildlife in slightly different locations. There has been some streamlining: Items can be crafted on the fly, and as the game is almost completely linear, a rhythm develops of entering an area, bringing up the Survival Instinct (essentially Detective Mode, another *Batman* parallel), which highlights interactive objects, then sneakily running from one to another. There are lots of things to collect, from ancient coins to crafting materials to ammo, and there's almost always one behind the level's starting position.

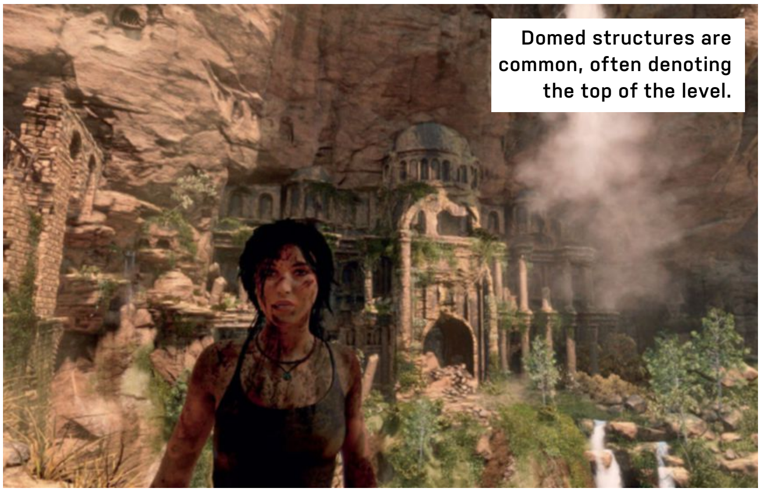
Returning to locations with equipment such as a combat knife (though you've been skinning animals for ages by this point, so cutting clearly isn't a problem) or rope opens up new avenues, and you're explicitly informed of this with a pop-up as well as vocally by Lara, rather than becoming stuck and frustrated, which is good game design even if it does break the spell.

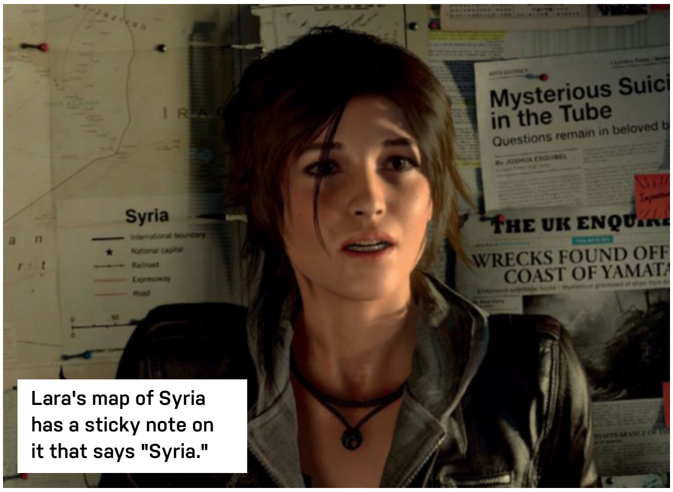
The level of hand-holding a player needs is a tricky balance to strike. Damage to Lara is shown by a gradual bloodying of the screen, but on normal difficulty, she is surprisingly resilient, even when faced with a bear. You're prompted to button-mash to open certain chests or rotate mechanisms, but not always to dodge out the way of an incoming paw with six-inch claws. When you get it right, it's satisfying to see Lara dance her way to safety, but it can occasionally be frustrating if your dying thought is, "Well, why didn't you tell me?"

You can get too involved in the stealth, too. We distracted and quietly killed some


The Soviet gulag acts as a hub, with lots to explore and discover.


Ice axes make climbing easier and can be used to rip down unstable walls.


Domed structures are common, often denoting the top of the level.



Lara's map of Syria has a sticky note on it that says "Syria."

guards around an oil tank, only to blow it up to exit the area—we could have just done that first and saved the arrows. There's no alternative to killing—this isn't *Deus Ex*, in which ducts can be used to bypass enemy encounters completely—and with a body count somewhere north of a small war, Lara's surely a good fit for the FBI's Ten Most Wanted list. She certainly seems to move in and out of war-torn countries with the ease of Osama Bin Laden.

DASTARDLY AND MILITARY

This tomb raider is naturalistic and wears her feelings openly, the excellently written dialog going a long way to underline her personality. This is the grenade-launcher-toting Lara from the end of the first game, given a whole new playground, rather than the inexperienced and hungry castaway who wept over killing a deer. Playing the role of Nazis to this modern-day Indiana Jones is the mysteriously well-staffed militaristic secret society Trinity, which likes to stamp its logo on things and is pursuing supernatural artifacts that exist only so Lara can get to them first. They are suitably dastardly, if a bit dim, and provide enough of a narrative urge to keep you moving forward.

Optional "challenge tombs" offer many of the best bits in the game. Their entrances require a little bit of searching out, although an on-screen prompt tells you when one is near, and you can ignore them to plow on with the main plot. But to do this is to pass over some wonderful sights and puzzles, some taking inspiration from Nintendo's finest work.

The game really is a looker. The world of snow-covered wastes could be an excuse for lackluster design, and some of the interiors tend toward the brown, but Lara explores places that feel genuinely designed, an artist's eye passing over the smallest details, be they the hooks that attach skeletons to walls, the patches of sunlight falling naturally on the right route to take, or the great war galley frozen vertically in ice. The invisible forcefield that pushes the snow down just in front of Lara's legs means she leaves a believable trail as she wades through thigh-deep drifts, while the birds and rabbits that cavort in the icy landscape add to the atmosphere.

Even if you didn't play the 2013 game, you should definitely play this. Stick the difficulty on easy (Adventurer) and enjoy the exploration if you're not getting into the shooting. While not remotely original, the systems are finely honed, the writing and performances top-notch, and the world artistically dense. **–IAN EVENDEN**

VERDICT
9

Rise of the Tomb Raider

+ RAIDER Looks great; excellently written; many believable locations and characters.

− FADER Combat is the least interesting part; the best puzzles are sidelined in optional sections.

RECOMMENDED SPECS Intel Core i7-3770 3.40GHz or AMD FX-8350 4.0GHz, 8GB RAM, Nvidia GTX 970 or AMD R9 290x, 25GB available storage.

$50, http://tombraider.com, ESRB: M

LAB NOTES

JARRED WALTON **SENIOR EDITOR**

Oculus Rift Costs $600

The price for VR early adopters

One day, lad, all this can be yours! (Once you've saved $600.)

SINCE THE OCULUS RIFT was Kickstarted back in 2012, we've been eagerly awaiting the first consumer release (CV1). As we go to print, the final hardware is complete, pre-ordering is available with a starting ship date of March 28, and we now know the official retail price. Get ready for a kick in the gut, as the formerly "$300–$400" Rift will officially set you back $600. That's 50 percent over budget, and the resulting nerd rage on the Internet is hardly a surprise.

I get that, but I also wonder how many of these people actually tried the earlier DK1 and DK2 variants. They were finicky, uncomfortable, made of cheap plastic, and sported headache-inducing 720p and later 1080p 60Hz displays. When you consider the upgraded 2160x1200, 90Hz display, better head-tracking, improved materials and build quality, plus the inclusion of an Xbox One wireless controller, the price isn't that shocking.

But even with all of those improvements, CV1 is still very much in the early-adopter phase. There aren't many triple-A games available yet, though there are quite a few indie titles. There will inevitably be future Oculus models, and as more consumers buy the hardware, we'll see more games, leading to more sales, and eventually we should see lower prices.

Oculus may not sell as many CV1 headsets at $600 as it would at $400, but CV1 pre-orders have already slipped to shipping in July, so clearly the high price isn't halting sales. Once inventory stops selling out, the prices should come down; hopefully, we'll have more games by then. Meanwhile, if you really believed in Oculus during the Kickstarter campaign, and pledged enough to get DK1, you'll receive a special edition of CV1 as a thank you, which is pretty generous if you ask me.

JIMMY THANG

Online Managing Editor

Every year, CES seems to revolve around certain trends. In the past, it was all about mobile. Then it was all about wearables and Internet of Things, er, things. This year saw the rise of drones and Virtual Reality. Also, RGB LEDs were huge this time round. Pretty much everything glows a radioactive hue now, and it seems as though we're moving on a path toward making the world of *Tron* become a reality. Of course, as usual, we saw a bunch of new, crazy things at CES, too—a water-cooled PSU, new tiny STX mobos, and a gaming AIO that enables you to squeeze in real desktop parts. Yep, it was CES all right, and I look forward to seeing where the industry is going to take us next.

ZAK STOREY

Staff Writer

Once again I find myself on the hunt for the perfect build. The thing is, when it comes to desk space, I haven't got a huge amount of room to play with. ATX is out of the question. Not a problem—I don't mind having one GPU, and I've always had a soft spot for ITX systems anyway. That said, in my eyes there's a severe lack of ITX cases out there that cater to my needs. And there are even fewer that support proper water-cooling. Thankfully, NZXT has saved my backside on this one. Its new Manta ITX chassis looks divine. Featuring curved steel panels, support for up to two 280mm rads, and a plethora of other neat features, I can't wait to get it into the office for review, and to build in.

Editors' Picks:
Digital Discoveries

Alan Dexter, executive editor, and Alex Campbell, associate editor, discuss their latest finds

ADATA HD720 1TB

Nearly everything I do these days involves storing data in the cloud. There's an important word at the start of that sentence, though: "nearly" is there for a reason. I'm loathe to trust everything to the cloud, and there are plenty of things that make more sense to store locally. An obvious one is video. If you're editing lots of home videos, you only really want to access them locally, at least until they're finished.

Adata recently sent through its HD720 for consideration, and it's made me rethink how I move around data in these days of always-on connections. Part of the reason is speed—hitting 110MB/s when copying across chunky video files is great, and there's a healthy 1TB of space, so plenty of room for my epic masterpieces. The fact it's a physical drive means I'm not reliant on ropey Wi-Fi connections either.

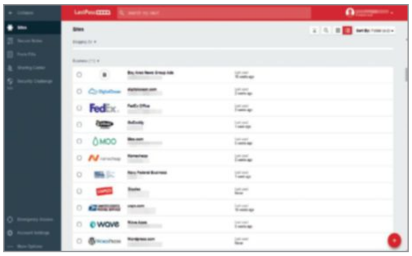
Admittedly, I don't really need the ruggedized side of the offering, but it's reassuring to know that if I do accidently take it into the shower, my files will be safe—it adheres to the IPX8 standard, so can be submerged two meters down for up to two hours. It's also dustproof (IP6X), military-grade shockproof, and the cable clips nicely around the edge. I take it everywhere now.
$106, www.adata.com

LASTPASS

There's a slew of apps and services I rely on, but few match the utility of LastPass. I tell pretty much everyone I meet to use a password manager, because using the same passphrase for multiple accounts can be downright dangerous.

I like LastPass because it encrypts your vault offline, before sending it to the cloud. That means if you forget your master passphrase, LastPass can't help. It also means that someone who breaks into LastPass's servers can't get at your vault as long as you use a strong master passphrase. It also supports a bunch of multifactor authentication options, such as Google Authenticator and Yubico's YubiKey U2F device. If there's one shortfall, though, it's in the U2F. When I use my YubiKey NEO's NFC for multifactor auth, LastPass locks me out on my iPhone 5S (no NFC), and won't let me use the add-on in Firefox for Android.

There's no such thing as absolute safety in the digital world, but using LastPass provides a good mix of security and convenience. It allows me to not have to remember complex passphrases, can fill in forms, and can help me audit my passphrases every so often. It's not perfect, but I'll take it over having to keep a notebook.
Free, https://lastpass.com



GEEK TESTED & APPROVED

Luxa2 Lavi O Wireless Earbuds

I'M ALWAYS on the lookout for good earbuds, mostly because I tend to lose them. I also have small ear canals, which makes it difficult to find a pair that fits well.

At this point, I generally prefer wireless earphones so that I don't have to deal with detangling cables all the time. That's why I was particularly excited to test the Luxa2 Lavi O Wireless Earbuds from Thermaltake, which sounded as though they might satisfy my needs (no pun intended).

The Lavi O earphones use 8mm drivers over Bluetooth 4.0, and they sound… OK. Generally speaking, audio quality is lost over Bluetooth. That's not to say they sound bad, but it's not as crystal clear as I would like. The wireless signal ranges from 10 feet outdoors to 30 feet indoors.

In terms of fit, the Lavi O offers three pairs of interchangeable earbuds of varying sizes. In my special case, even the smallest ones were a little too big for my ear canals, and would occasionally slip out when I wore them while exercising. In terms of battery, the Lavi O earphones have an 80mAh lithium-polymer solution, which lasts two to three days under heavy use.

So, while the Lavi O 'phones aren't perfect, and they're not an especially good fit for me, you can find them on sale for $25, which makes them a steal as far as Bluetooth earbuds go. **–JT**
$30, https://store.thermaltakeusa.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> Where's the EVGA Love?
> Review Scores
> Boot Order

EVGA FTW!

I'm a long-time subscriber to *Maximum PC*. I enjoy reading the reviews and finding out about the new stuff that's coming out. I've noticed over recent years, though, that there's been no EVGA love. Back in the day, when I got serious about building powerful machines, EVGA was the go-to company for all your needs. I can't remember the last time I read a review of one of their video cards or motherboards. It seems the Best of the Best parts are between MSI, Gigabyte, and Asus. Yet the Dream Machines 2015, 2014, 2013, 2012, 2011, and 2010 (2010 was an EVGA mobo)—that's as far back as I looked—all housed EVGA cards. Even the builds in the back of the magazine use EVGA stuff, but I have yet to read any reviews of its products (EVGA makes power supplies, but I haven't seen any reviewed yet). What's the scoop on that? Can we please get some EVGA love and some other brands? **—Eric**

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Eric. Our reviews are typically done with the hardware we have on hand, and certain items—graphics cards in particular—all end up being very similar. I've used and tested several EVGA graphics cards (GTX 950/960/980/980 Ti), and they're all good. Are they substantially better (or worse) than the competition? Not really, so most of our reviews use a reference GPU if available (from AMD or Nvidia) rather than a specific brand (though we do use brand units for testing graphics cards, as opposed to GPU launches). Basically, EVGA is a great option for graphics cards, often with good pricing on base models and a good warranty.

Power supplies are a similar story. There is only a handful of companies that actually make power supplies—everyone else uses these companies to build PSUs to their specifications. For its part, EVGA uses FSP Group and Etasis on some models, and I believe its beefy 1,600W Titanium PSU is made by Super Flower. It's a great PSU, and it also costs a ton. In general, the vast majority of 80 Plus Gold rated PSUs are very good, and I've rarely had issues with even 80 Plus Bronze or higher PSUs. And I'll be honest: Reviewing PSUs requires a lot of specialized equipment to do properly; it's not something we're set up to test right now. (Read Jonnyguru.com if you're looking for detailed PSU reviews and information.)

Motherboards are much more complex, so even if all the pieces appear to be in place (chipset, features, capacitors, and so on), it's still very easy to mess up the firmware/BIOS, and end up with a less-than-stellar product. Despite its status as an enthusiast brand, EVGA's motherboards have been less consistent than its graphics cards and PSUs; none are terrible, but they're often not worth the price premium. In many cases, there are better boards from the tier-one manufacturers (Asus, Gigabyte, and MSI). These three have the best QA and testing, the most experience (they've all been around for decades), their firmware and BIOS code has the fewest issues, and they're more responsive. Which isn't to say that all boards from the big three are great, or that all boards from other manufacturers (ASRock, Biostar, ECS, EVGA, Foxconn, and so on) are bad. However, many

[NOW ONLINE]

HOW VR IS REVIVING 3D AUDIO

If you've been following PX 3D audio, you know that the medium has seen better days. As a matter of fact, 3D audio was actually more promising and impressive in the 1990s than it is today. In our online story "How VR Is Resurrecting 3D Audio," we break down the fall of the audio revolution, but also get into the medium's bright future. Because VR is so heavily reliant on 3D audio for immersive experiences, it's due to come back with a vengeance. For the in-depth story, check out the web exclusive. http://bit.ly/MPC_3Daudio

↘ submit your questions to: comments@maximumpc.com of us have had some poor experiences with various motherboard brands, so we don't take a lot of risks—there's too much that can go wrong. The good news is we're working on putting together some reviews of the latest motherboards, and all brands are welcome; the bad news is that thoroughly testing a mobo can be extremely time-intensive, and with so many boards (Newegg lists 200 Skylake-compatible boards), there's no way we can test them all.

So, in summary: We do test EVGA, as well as other brands, but time is limited and space in the magazine is even more limited. Check our website for additional reviews, but at best we only test a small percentage of the various brands and models of hardware.

Numbers Game

I have a quick question regarding the monitor roundup in the February issue ("Flat-Panel Perfection," p26). The BenQ 2765 HT received an 8 in the January issue, but got a 9 Kick Ass award in the February issue. Was that a rating based on the available 11 monitors it was in competition with, or was it a different model that I'm unaware of? Thanks for clarifying (it might be the 2560x1440p monitor I buy in the near future). **—Chad F**

EXECUTIVE EDITOR ALAN DEXTER RESPONDS: Hi, Chad. Yes, it is the same display, but we revised the score upward to make it clearer which screen we recommend right now. There are lots of really great monitors available at the moment, but it wasn't until we sat down with a whole host of them that we realized just how good the BenQ really was.

If you're in the market for a display at the moment, this is definitely the one to get—great image quality at a decent price. It may lack some of the headline-grabbing features of others, but it does the fundamentals very, very well.

To be honest, we were gutted when we had to send ours back.

Get Boots in Order

Good answer regarding booting with UEFI and SSD, but the problem is what you did not say. You should have advised the writer (and other readers) to go into their BIOS or UEFI and change the boot order right now, before there is a boot problem.

If the first listed boot device is the internal HDD or SSD, the PC/laptop will continue to have a boot problem due to the speed of the boot. Now is the time to change the boot order to a recovery disc, external HDD, or USB, before the internal HDD or SSD, to have a chance of an alternative boot method. **—Gerald Gibson**

SENIOR EDITOR JARRED WALTON RESPONDS: Hi, Gerald. Part of the difficulty in giving advice is that there are so many ways things get done on modern systems. I have a few desktops where even now, using UEFI and Windows 10, I can easily access the BIOS by pressing Delete or F2 after powering on. I don't know that I've seen any system where I couldn't get into the BIOS after a cold boot, though there probably are examples; my original response was more directed at the problem of accessing the advanced startup menu. I know laptops tend to be a lot more variable in how they do things, but even if you can get into the BIOS, there's usually not much to change. Modifying boot order to make it easier to get into the BIOS only helps if the system is built such that there's no boot option menu available, which usually only happens on corporate laptops in my experience (in which case, the IT department doesn't want you changing BIOS settings).

If you enable a boot device menu, doing this will often increase the POST time by a second or two. Then again, how many of us really complain about the difference between booting in eight seconds versus booting in 10 seconds? It's that dreaded law of diminishing returns—going from HDD to SSD and booting in 20 seconds instead of two minutes was awesome; moving from a good SSD to a superb SSD with an optimized BIOS and cutting boot times to 10 seconds is still nice, but not quite so critical; going from ten to five seconds, even though it's "twice as fast," isn't really that important when most of us only boot their PC once a day (if that).

But I digress... again. I'm with you that every laptop/system is easier to troubleshoot if you can boot from a USB drive when things go bad. IT administrators, on the other hand, tend to like laptops, in particular, to be locked down. The good news is that if anything does go wrong on a company laptop, and the IT department locked down the boot options, you can simply take the laptop to the IT department to get it fixed.

Facebook Polls

Do you use external DACs for audio, or are you satisfied with onboard audio?

Bob Malloy: I still use my Creative Extigy. It's 15 years old and still works fine.

Michael Tuzzolino: Onboard. With 5.1 Logitech speakers.

Harold Love: Sound Blaster ZX here. Works well, been happy with it and my AKG K240 MkII headphones. I would like a Schiit Audio setup.

Darren Lee: Give a try on the Magni 2 and Modi 2 combo. You won't regret it.

Bryan A Flood: I use a PCIe card, as onboard audio just eats up CPU cycles needlessly and the audio gets distorted.

Ed Silow: Schiit Modi 2/Magni 2 stack driving Beyerdynamic DT880 Pro headphones and a pair of Mackie MR5mk3 studio monitors.

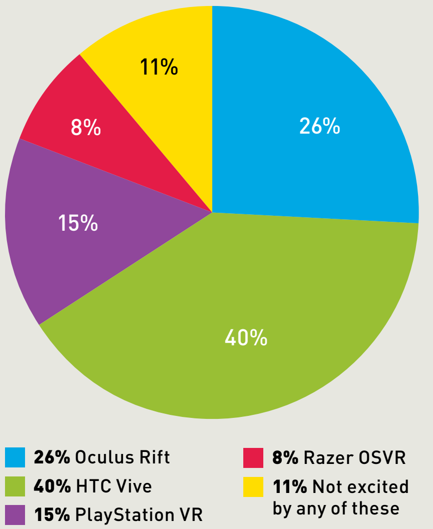
Nick Holt: Creative ZxR but have upgraded to a Fostex DAC/amp for my high-end headphones.

Michael Green Xonar: STX soundcard, but I wouldn't recommend it to anyone else. Software is just clunky and awful. External DAC next time.

Zane Gaston: I'm fine with onboard if shielded, and I'm using low-impedance headphones. If I'm using bigger ones, I'll use a small USB amp/DAC combo. I really want a Schiit stack, though.

Ahmed Adel Habib: Quite content with my onboard: Asus Maximus VI Formula z87.

Which VR system are you most excited about?



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THE BUILDS

BUDGET GAMER

INGREDIENTS

PART		PRICE
Case	Cooler Master Elite 110	$40
PSU	Corsair CS450M 450W/80 Plus Gold	$70
Mobo	Gigabyte GA-H170N-WIFI **NEW**	$120
CPU	Intel Core i5-6400 **NEW**	$190
GPU	EVGA 1962-KR GeForce GTX 960 SC	$200
RAM	8GB (2x 4GB) G.Skill Ripjaws V Series DDR4 2133	$42
SSD	250GB Samsung 850 EVO M.2 **NEW**	$92
OS	Ubuntu 14.04.3 LTS 64-Bit **NEW**	$16

Approximate Price: $770

WE MADE A SWAP of mobos, opting for Gigabyte's H170. It didn't cost much more but to offset the price we dipped down to a Core i5-6400—nearly the same chip as the i5-6500, but with lower clocks and no trusted computing module. As we're running Ubuntu, we don't care as much about trusted computing. As for clock speeds, the CPU still gets a turbo of up to 3.3GHz. We held off jumping up to a Z170 board. Some Z170 boards allow overclocking non-K Skylake CPUs by altering the base clock, instead of multiplier and voltage, but you lose Intel's integrated graphics, and the CPU can't regulate its power. That means we'd need water cooling or a big air cooler, which adds to the cost. We also replaced the SATA Samsung 850 Evo with its M.2 cousin. This means less clutter. We used the latest LTS release of Ubuntu, too. It builds upon 14.04 with updated software packages and even turns off much-hated web search in the dash by default.

MIDRANGE

INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro M	$70
PSU	EVGA SuperNOVA G2 650W	$100
Mobo	MSI Gaming Z170A Gaming M5 **NEW**	$160
CPU	Intel Core i5-6600K	$257
Cooler	Corsair H80i	$88
GPU	Asus R9 390 Strix 8GB	$340
RAM	16GB (4x 4GB) G.Skill Ripjaws 4 Series DDR4 2400 **NEW**	$85
SSD	500GB Samsung 850 EVO M.2	$168
HDD	Western Digital Black Series 2TB 7,200rpm	$128
OS	Windows 10 (*Download*)	$110

Approximate Price: $1,506

SOMETIMES, WE'RE SURPRISED by prices. We decided to upgrade the mobo to MSI's Z170A Gaming M5, which offers dual M.2 and two-way SLI, and three-way Crossfire support. That set us back about $30 more than last month's Gigabyte board, but it's money well spent. The Phanteks case dropped $20, the Core i7-6600K came down about $13, and the RAM came down, too. We got 16GB of G.Skill Ripjaws 4 Series DDR4-2400 for $85. The Samsung 850 Evo came down about $3, while our WD Black went up about $8. The Asus R9 390 Strix's price didn't move; with the Crossfire support on this mobo, there's a clear upgrade path through buying a second R9 390. There's also plenty of other places to upgrade. While the Core i5-6600K will keep most happy, there's the option to upgrade to the Core i7-6700K. However, the more interesting upgrade is another M.2 SSD—there are some great read and write speeds to be achieved with software RAID.

TURBO

THE TURBO BUILD isn't a place we always anticipate seeing savings, but in this case, we saw quite a few. The first thing we noticed was a price drop of $15 on the PSU. That's not bad, and we made good use of that later on while we were shopping. We also saw a $5 drop on the price of the CPU. While we've expected to see Skylake prices fluctuate, Haswell-E CPU prices have remained pretty stable. Any price change (especially downward) catches our eye. Our motherboard also dropped $5. For anyone who's counting, that puts us $25 cheaper than last month. Of course, our twin GPUs always deliver the pain to the wallet, but this month we found a couple of PNY reference GTX 980 Tis on sale that collectively saved us another $20. We're up to $45 in total now. Next, we ditched our twin 16GB 4x4 kits for a single 32GB 4x8 kit. We also decided to drop the speed to 2,666MHz, which rendered us some more savings. To be exact, we pulled in $36 in savings. Like our Midrange build, the 500GB M.2 Samsung 850 Evo came down just a smidge as well. So what did we do with these savings? We plunked down the cash needed to double the storage space in our spinning HDD. It's not the most ambitious upgrade, to be sure, but upgrades for core components on the X99 platform often run in the hundreds (upgrading to the i7-5930K, for example, would have cost us an extra $195).

For more of our component recommendations, visit www.maximumpc.com/best-of-the-best

INGREDIENTS

PART			PRICE
Case	Corsair Graphite 780T Black		$180
PSU	EVGA SuperNOVA G2 1,000W		$165
Mobo	Asus X99-A/USB 3.1		$265
CPU	Intel Core i7-5820K		$385
Cooler	Corsair H80i		$88
GPU	2x PNY GTX 980Ti (*Reference*)	**NEW**	$1,280
RAM	32GB (4x 8GB) Corsair Vengeance LPX DDR4 2666	**NEW**	$174
SSD	500GB Samsung 850 EVO M.2 (SATA)		$168
HDD	Western Digital Black Series 2TB 7,200rpm	**NEW**	$128
OS	Windows 10 (*Download*)		$110

Approximate Price: $2,943

UPGRADE OF THE MONTH

SAMSUNG 950 PRO 512GB

V-NAND SSD
950 PRO M.2
NVM Express
512GB
SAMSUNG
RATED: DC+3.3V⎓2.7A

We've looked at the Samsung's 950 Pro before, but this time we got to play with the 512GB version. If you're looking at consumer NVMe SSDs, you really can't do much better than the 950 Pro.

But this speed will cost you. For roughly the cost of one of these, you can get two 500GB 850 Evo SATA M.2 SSDs. (We found the 950 Pro for $328 on Newegg.) Coupled with the fact that very few consumers could even make use of the speed the 950 Pro offers, this is an enthusiast part for sure.

$328, www.samsung.com

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